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REVISION 1

GOSS DATA BOOK

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(CONTAINS SECTIONS 4, 5, AND 6)

PRELIMINARY

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FOREWORD

The GOSS Data Book provides a central source of data, in summary form, on the facilities and subsystems comprising the Ground Operational Support System. This document is being submitted in compliance with paragraphs 2.8, 2.3.4, and 2.1.5 in Exhibit A, Statement of Work, MSC Requirements for Manned Space Flight Support, dated March 1963.

Contents of this data book reflect the inputs of the various groups or contractors working towards definition of the GOSS. Therefore, the data presented will be revised periodically to reflect developments in the various areas of responsibility.

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SECTION 4

GOSS SUBSYSTEMS

4.1 GENERAL

(To be provided later.)

4.2 TELEMETRY NETWORK

4.2.1 Sources of Information

The primary sources of information used in the compilations of the data given in this section are as follows:

a. "GOSS Telemetry Network Data Book," PHO-1Z4000.

b. "Operation and Maintenance Telemetry System—Project Mercury," MS106, Vol 1.

c. "GOSS Communications Network Data Book," PHO-1Z1000, Vol 1 and Vol 2.

d. "Program Instrumentation Requirements Document (PIRD)—Project Gemini," NASA/MSC

The following material provides a brief introduction to the telemetry capabilities of the GOSS network as a whole. Following this, the network configurations for the manned Gemini and Apollo missions are discussed.

Figure 4.2-1 shows the geographical locations of all GOSS stations, and the telemetry capabilities of each station are indicated by symbols. Operational facilities are arranged according to the major subsystem types which are found at the various GOSS stations.

4.2.2 Gemini Configuration

A simplified block diagram of the telemetry network is given as Figure 4.2-2, while Figure 4.2-3 is a detailed block diagram of the

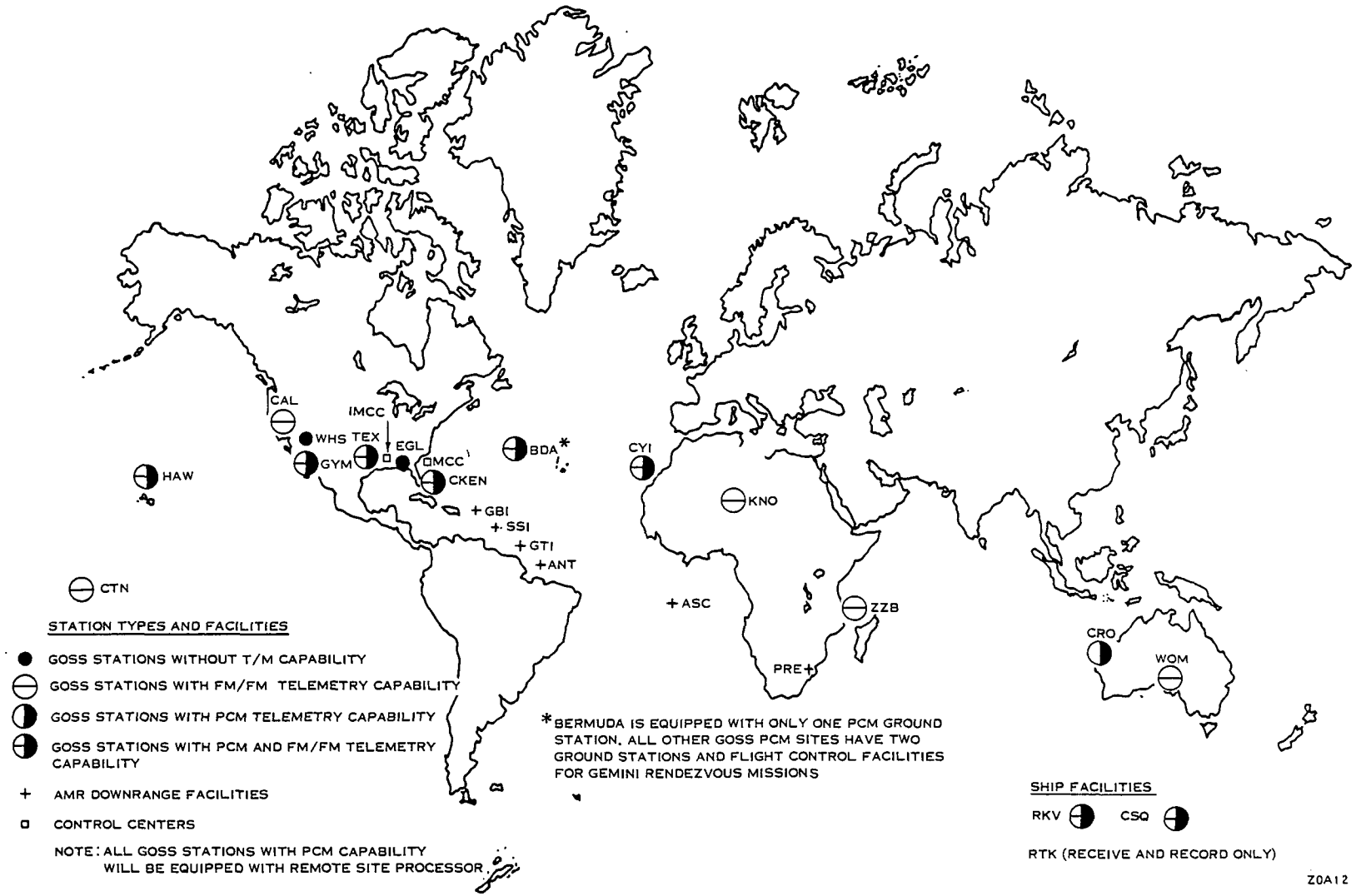


Figure 4.2-1 GOSS Stations and their Telemetry Capabilities

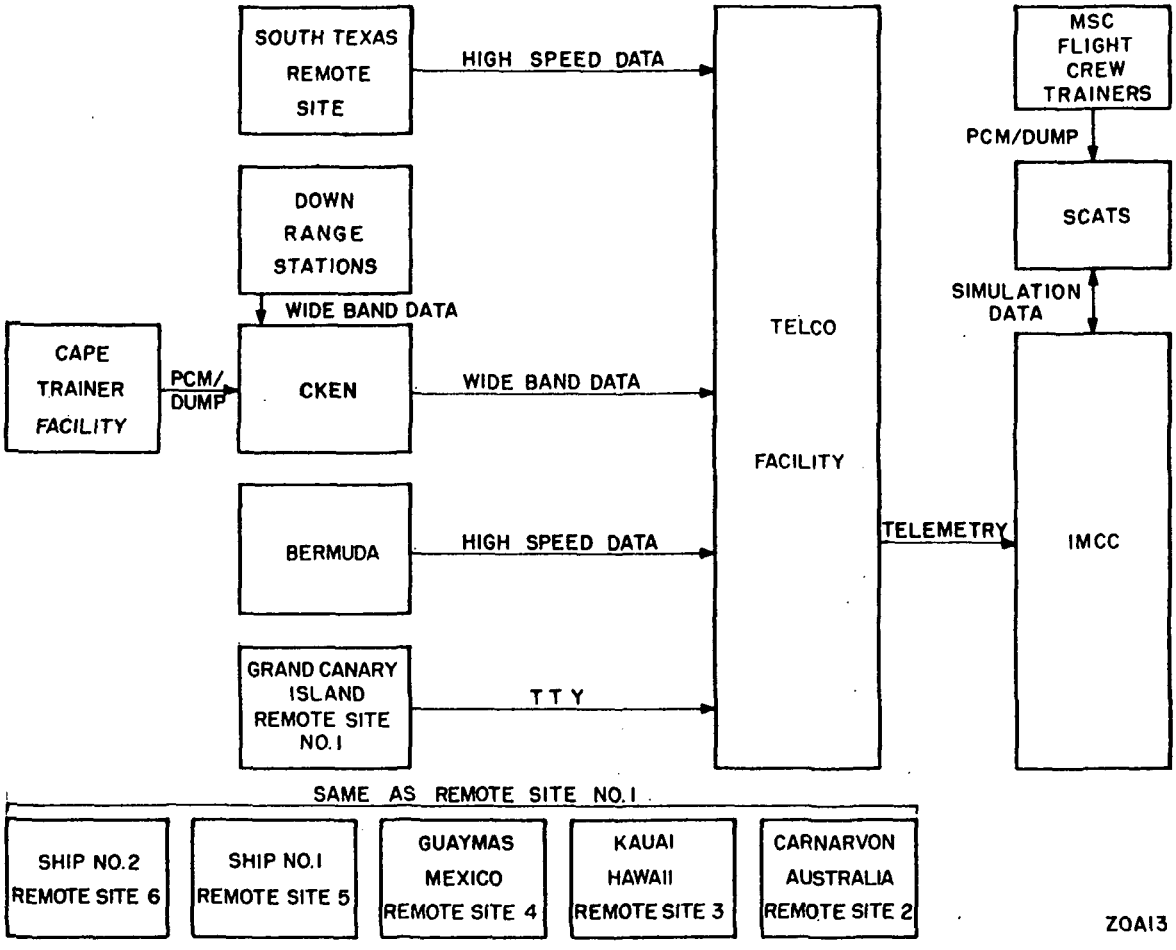
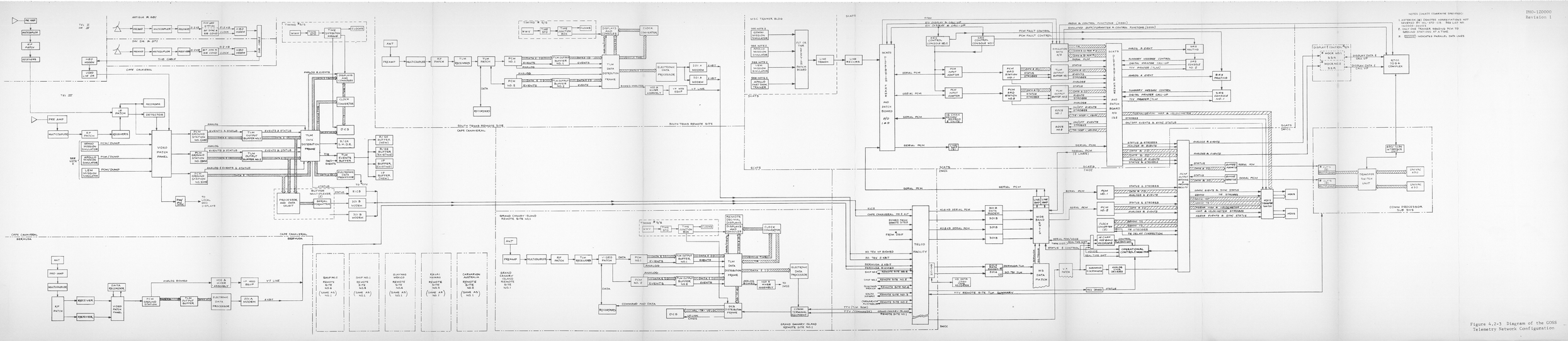


Figure 4.2-2 Simplified Block Diagram of the GOSS Telemetry Network Configuation


NOTES (UNLESS OTHERWISE SPECIFIED):
1. ASTERISK (*) DENOTES ABBREVIATIONS NOT QUOTED BY MIL STD 12 B. SEE LIST NO. 1430081-00003.
2. ALL MODEMS NUMBER REMOVAL PCM TO GROUND STATIONS AT A TIME.
3. ||||||||| INDICATES PARALLEL DATA LINES.
CAPE CANAVERAL
BERMUDA
SOUTH TEXAS REMOTE SITE
GRAND CANARY ISLAND REMOTE SITE NO.1
SHIP NO.1 REMOTE SITE NO.6 (SAME AS NO.1)
SHIP NO.1 REMOTE SITE NO.8 (SAME AS NO.1)
BUOYMO VESSEL REMOTE SITE NO.8 (SAME AS NO.1)
KAUAI HAWAII REMOTE SITE NO.5 (SAME AS NO.1)
CARNARVON AUSTRALIA REMOTE SITE NO.2 (SAME AS NO.1)
SCATS
SCATS (MCC)
SCATS (MCC-H)
SCATS (MCC-H) INCO
SCATS (MCC-H) DATA PATCH BOARD
SCATS (MCC-H) AUDIO PATCH BOARD
SCATS (MCC-H) VOICE PATCH BOARD
SCATS (MCC-H) DATA PATCH BOARD NO 1 & 2
SCATS (MCC-H) AUDIO PATCH BOARD NO 1 & 2
SCATS (MCC-H) VOICE PATCH BOARD NO 1 & 2
SCATS (MCC-H) DATA PATCH BOARD NO 1
SCATS (MCC-H) AUDIO PATCH BOARD NO 1
SCATS (MCC-H) VOICE PATCH BOARD NO 1
SCATS (MCC-H) DATA PATCH BOARD NO 2
SCATS (MCC-H) AUDIO PATCH BOARD NO 2
SCATS (MCC-H) VOICE PATCH BOARD NO 2
SCATS (MCC-H) DATA PATCH BOARD NO 3
SCATS (MCC-H) AUDIO PATCH BOARD NO 3
SCATS (MCC-H) VOICE PATCH BOARD NO 3
SCATS (MCC-H) DATA PATCH BOARD NO

telemetry network, both of which illustrate the three basic types of inter-station telemetry data flow, which, together with the various equipments and subsystems, are used throughout the TLM network. Detailed station-by-station equipment listings and additional data are given in the tables of Section 3.4.

a. Remote Site Processor. Each GOSS remote site with PCM telemetry capability will be equipped with a Remote Site Processor. This will utilize a UNIVAC 1218, which is a general purpose, medium scale, solid state computer. (See Section 6.7.9.) It will provide, as its primary function, an output of telemetry data suitable for transmission to the IMCC and be compatible with available transmission facilities. Outputs will consist either of non-real-time summary messages to be transmitted by TTY, or, in the case of Bermuda and Corpus Christi, real-time data at greatly reduced sampling rates to be transmitted via HSD facilities.

b. Summary Messages. Remote sites will utilize teletype links to transmit summary messages to the CKEN/MCC or the IMCC. These summary messages will be generated automatically at each site by the Remote Site Processor. Special summary message formats will be available for use in contingency situations. The messages will be transmitted to the IMCC or the CKEN/MCC via teletype communications circuits. Upon reaching the destination, the messages will be processed automatically. In the IMCC, the TTY summary

data will enter the RTCC via the Communications Processor Subsystem, which will reformat and retransmit the received data to other stations in the network and generate hard copy reports. (See Tables 4.2-1 and 4.2-2 for the respective Gemini and Agena summary message formats.)

c. High Speed Data. Telemetry data from the Corpus Christi and Bermuda sites will be transmitted in a compressed real-time format via high speed data (2K bps) circuits. The 2K bps data stream will be formatted by the remote site processors. This data stream is divided into 250 8-bit words, which breaks down further as follows:

Sync	3 words
Message Acceptance Pulse (MAP)	20 words
Data	227 words
Total	250 words

The 227 data words may be super- or sub-commutated as further requirements dictate.

The High Speed Data entering the IMCC will be routed to one of the PCM ground stations via the Wide Band Switch. The decommutated data will then enter the RTCC via the Communications Processor Subsystem. Certain Digital-to-Analog Converter outputs and events are routed to MOCR. The high

Table 4.2-1 Gemini Summary Message Format

Format	Spacecraft System	No. of Parameters
Main Summary		69
Contingency A		45
Group 1	Electrical	4
Group 2	Environmental	15
Group 3	Communication	16
Group 4	Instrumentation	10
Contingency B		40
Group 1	OAMS and RCS	5
Group 2	ACMS	4
Group 3	IGS	13
Group 4	Radar	14
Group 5	Aerodynamics	4

Table 4.2-2 Agena Summary Message Format

Format	Spacecraft System	No. of Parameters
Main Summary No. 1		49 + Subframe C
Contingency No. 2		39
Group 1	Electrical	7
Group 2	Communications	10
Group 3	Guidance and Control	4
Group 4	PPS	6
Group 5	SPS No. 1	6
Group 6	SPS No. 2	6

speed data input processing performed by the RTCC will consist of unpacking the messages (frames of data), converting the data to engineering units, performing certain limit-sensing functions and special computations, alarm driving, and certain additional operations.

d. Wide Band Data. Wide Band Data (WBD) will be used to transmit real-time telemetry from the Atlantic Missile Range (AMR) to the IMCC. These data will be compressed to a format compatible with the 40.8K bps rate of the WBD facilities. The Buffer/Multiplexer performs the compression and reformatting. The Buffer/Multiplexer will accept, during a "worst case" operation (involving Agena, Gemini, and Titan TLM), an input of approximately 221K bps, consisting of the following:

Agena	16.38K bps
Gemini	51.20K bps
Titan	153.60K bps
Total	221.18K bps

Certain sync words will be removed from the Titan data, accounting for the reduced bit rate given above. The airborne Titan bit rate will be 172.8K bps.

Atlas data are not included in the above format, since no operational requirement exists for them.

The Wide Band Data entering the IMCC will be decommutated by one of the PCM ground stations and routed to the RTCC via the Communications Processor Subsystem. Certain Digital-to-Analog Converter outputs and events are routed directly to MOCR. The RTCC will process the information by converting certain data to engineering units, performing limit-sensing functions, alarm and display driving, and certain other operations.

e. Downrange AMR Data Flow. This area is not yet firm, and concrete information cannot be supplied at this time. Figure 4.2-3 will be revised in the near future to reflect the necessary changes.

f. Telemetry Ground Stations. Major characteristics of the telemetry ground stations utilized in the GOSS network are given in Table 4.2-3. The MSFTP-1 (EMR) will be utilized in pairs at all remote sites with dual PCM capability (rendezvous mission support). The Telemetric Units will be located at various AMR sites as indicated. The PCM ground stations for the IMCC have not been chosen as to specific type and manufacturer. Requirements, however, dictate a very flexible stored-program machine capable of accommodating up to ten separate formats.

g. Telemetry Links. A summary of all the space-ground telemetry links which must be supported by the GOSS network are given in Table 4.2-4.

h. Configuration by Mission Types. The configuration of the telemetry network for any particular mission or mission type is dictated by

Table 4.2-3 Telemetry Ground Stations

PCM	Locations	Programming	Word Length	Word Sync	Frame Sync	Max. Frame Length	Inputs	Outputs
MSFTP-1 (EMR)	CKEN BDA CYI CRO HAW GYM TEX RKV CSQ	Patchboard; 2 programs selected by switch	4-64 Bit	1, 2 or 3 Bits	Up to 64 Bits	4096 Bits	RZ, Split Phase & NRZ digital PCM bit stream; forward or reverse mag. tape playback	Parallel binary data, Parallel BCD data & Analog Events, Sync Information.
Telemetric Model 670	CKEN Downrange AMR	Stored program up to 6 formats	6-64 Bits	0 to 6 Bits	Up to 64 Bits	4096 Bits	Same as above plus Bi-polar	Same as above
IMCC*	IMCC	Stored program accomodating up to ten separate formats	4-64 Bits	**	**	**	Same as MSFTP-1	Same as above
FM/FM		Locations		Subcarrier Channels			Inputs	Outputs
Bendix, TDA-102, TDA-300. Some sites have Arnoux, decommutator TDS-90/30, TDS-90/90 etc.		CKEN BDA ZZB CYI CRO CTN HAW GYM CAL TEX GTI GBI RKV CSQ		Standard IRIG, See Equipment Lists, Sections 3.3.1 thru 3.3.20 for channels available at Each Site			IRIG Standard FM Subcarrier Analog Telemetry	Analog Voltage

* To be Procured
** Data Not Available at this Time

Table 4.2-4 Gemini Program Telemetry Links

A. GEMINI SPACECRAFT				
Frequency (mc)	Flight No. 1		Subsequent Flights	
	System	Use	System	Use
230.4	FM/FM	Real-Time	PCM/FM	Real-Time
246.3	FM/FM	Real-Time	PCM/FM	Stored Information (Dump)
259.7	FM/FM	Real-Time	PCM/FM	Standby Xmtr
B. AGENA TARGET VEHICLE				
	System	Use		
240.2	PCM/FM	Real-Time		
248.6	PCM/FM	Stored Information		
C. TITAN LAUNCH VEHICLE				
	System	Use		
244.3	PCM/FM	Real-Time Launch TLM (Prime Source)		
237.0	FM/FM	Playback of data recorded during staging blackout; certain real time functions		
D. ALTAS LAUNCH VEHICLE				
	System	Use		
229.9*	PAM/FM/FM	Real-Time Launch TLM		
232.4*	PAM/FM/FM	Real-Time Launch TLM		

* Allocation Requested

data requirements for operational control and engineering analysis. Diagrams and brief discussions are presented to illustrate the network configurations which are required for each type of Gemini mission.

i. Manned Non-Rendezvous Missions. Figure 4.2-4 depicts the network as it will be utilized for manned Non-Rendezvous Missions, beginning with GT-3. Worldwide coverage will be provided, with all PCM telemetry-equipped stations of the GOSS network participating. The Integrated Mission Control Center is expected to become operational in time to serve as the central control facility for one or more of the later manned non-rendezvous flights. The telemetry network configuration will be quite similar to that on Figure 4.2-4 except that the IMCC will be used for central control instead of the CKEN/MCC.

When the IMCC becomes operational, compressed TLM data will be received from the AMR via a wide band circuit, as mentioned earlier.

j. Manned Rendezvous Missions. Figure 4.2-5 illustrates the telemetry network as it will be configured for the Gemini Rendezvous Missions, starting with GT-5. The simultaneous two-vehicle support capability of the network will be exercised during these missions.

k. Telemetry Types and Formats. The first Gemini-Titan flight (GT-1) will utilize an FM/FM telemetry subsystem for the Gemini spacecraft. The Titan launch vehicle will carry a PCM/FM subsystem and an FM/FM subsystem (Table 4.2-4).

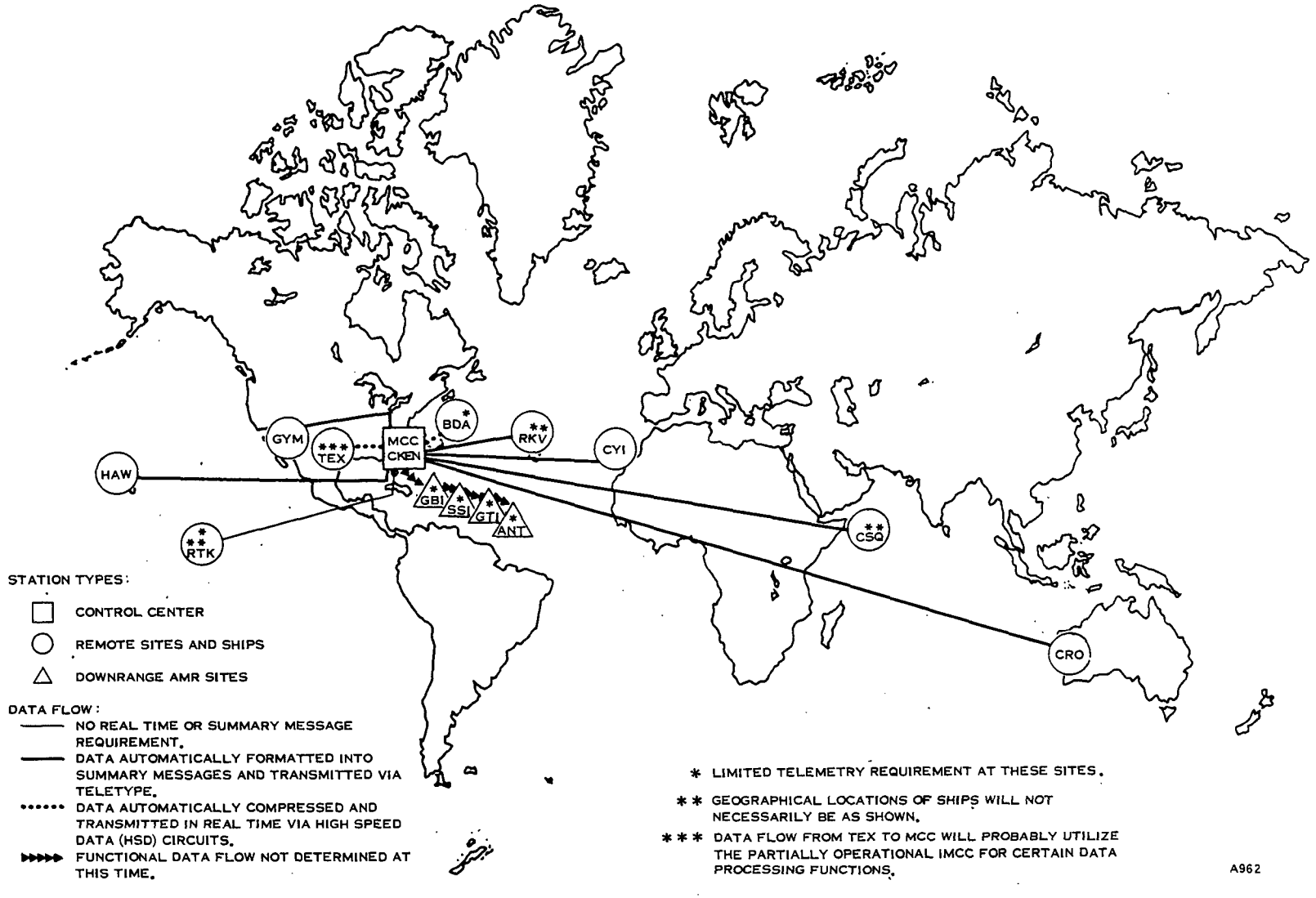


Figure 4.2-4 GOSS Telemetry Network Configuration for Manned Non-Rendezvous Missions Utilizing the Mission Control Center at Cape Kennedy

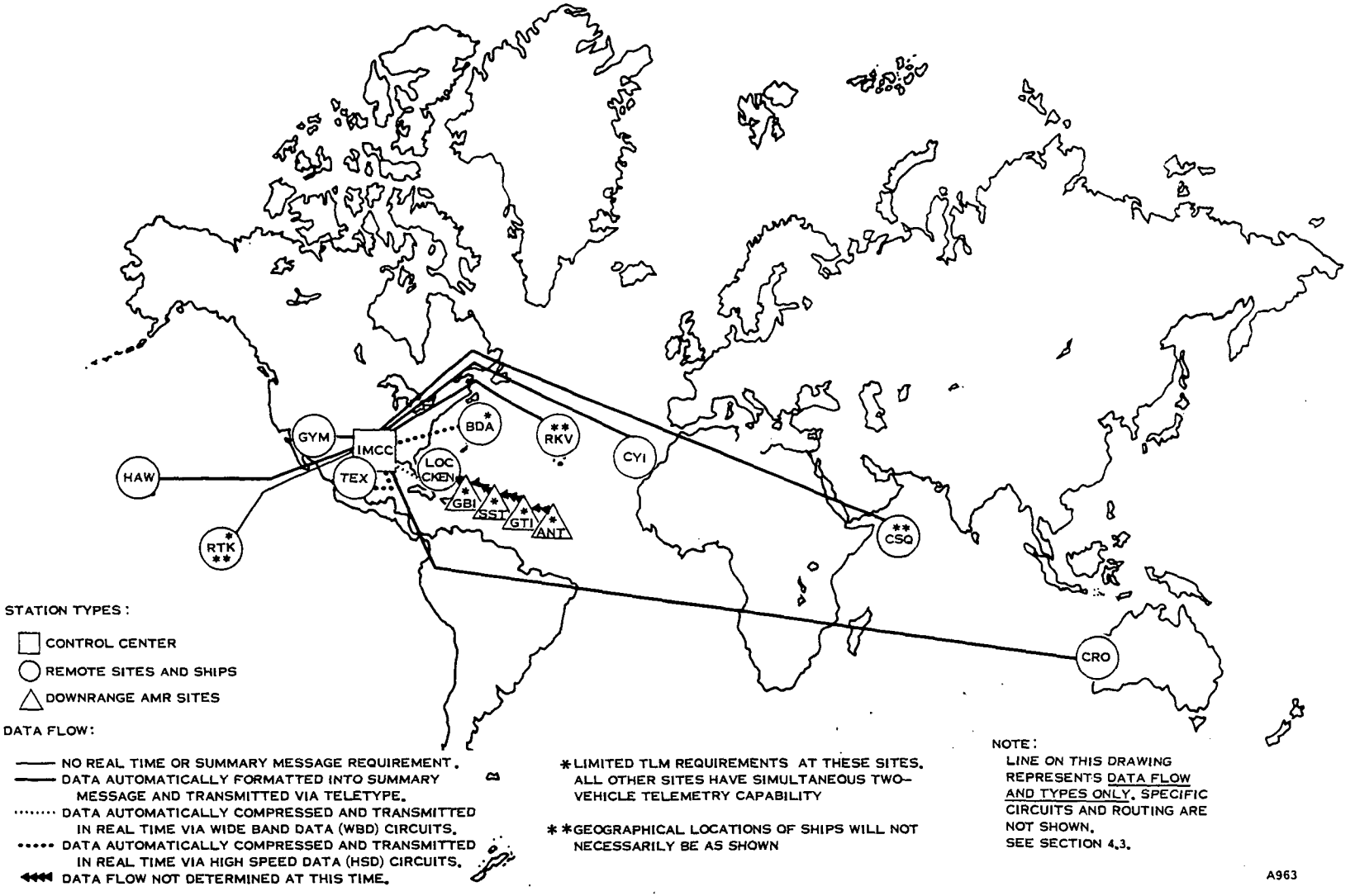


Figure 4.2-5 GOSS Telemetry Network Configuration for Manned Rendezvous Missions

The GT-2 flight, and all subsequent Gemini flights, will employ only PCM/FM telemetry for the Gemini Spacecraft. The Agena target vehicle will also employ PCM/FM telemetry exclusively. Telemetry links for the Titan launch vehicle is standardized and will be the same for each Gemini launch, as indicated in Table 4.2-4. (The same comment also applies to the Atlas boosters used to launch Agena target vehicles.)

1. PCM Formats. PCM ground stations receiving orbital vehicle TLM data will be required to accommodate formats as they appear for each of the following:

- Gemini Spacecraft real-time TLM
- Gemini Spacecraft dump TLM
- Agena Target Vehicle real-time TLM
- Agena Target Vehicle dump TLM.

m. Gemini Format. Figure 4.2-6 shows a mechanical analog of the Gemini TLM format, given as an aid to the understanding of the manner in which the Gemini telemetry data are assembled into the format which is transmitted from spacecraft to ground.

The format used for Gemini spacecraft telemetry is based upon a master frame consisting of 160 data words (assigned to "word slots" numbered from 1 to 160). Each word contains 8 bits. Forty of these master frames are transmitted each second, producing an output rate of 51.2K bps. Super-commutation is employed wherever it is desirable to look at a parameter

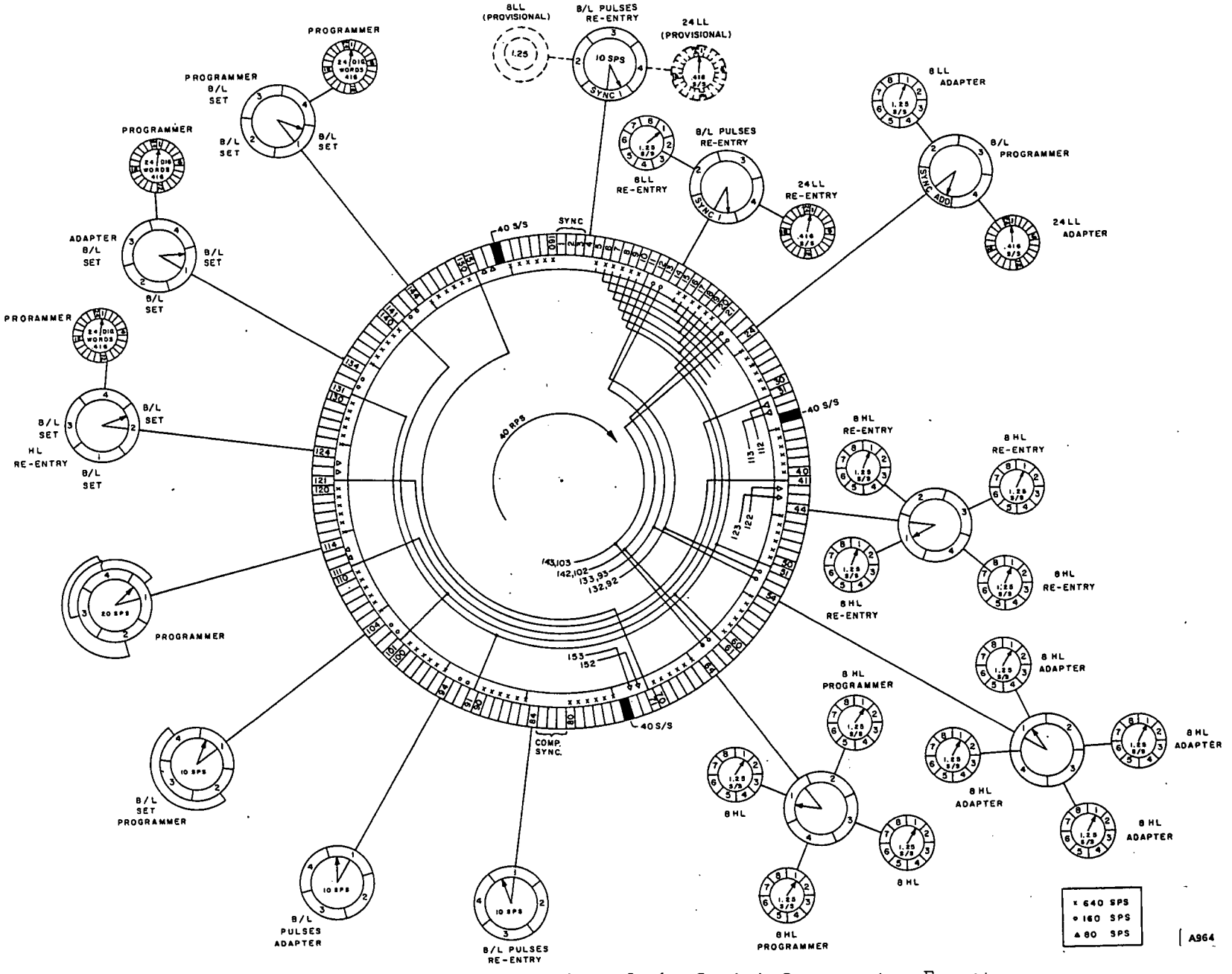


Figure 4.2-6 Mechnaical Analog of the Gemini Commutation Format

more often than one time per master frame. This means simply that several "word slots" in the master frame will be assigned to the same parameter, resulting in the parameter being sampled several times per master frame. Three supercommutation rates are used for Gemini, as follows:

- 16 words per master frame, or
  16 X 40 = 640 samples per second
- 4 words per master frame, or
  4 X 40 = 160 samples per second
- 2 words per master frame, or
  2 X 40 = 80 samples per second.

Subcommutation is used whenever a parameter is not required to be sampled in every successive master frame. Each subcommutated word slot may then be "time shared" to accommodate a number of different parameters, that is, a subcommutated channel shared by four parameters would cause one of the four parameters to appear every fourth master frame.

A scheme of sub-subcommutation is also used to telemeter certain parameters which are sampled even more infrequently. For example, word Nos. 134 and 144 of each master frame are subcommutated at a ratio of 4:1 and then subcommutated again at a ratio of 24:1. This results in a 96:1 subcommutation ratio. This means that a parameter sub-subcommutated in this fashion appears every 96th master frame, or approximately once every 2.4 seconds. Other subcommutation ratios used are 32:1 and 4:1.

Certain data words contained in the master frame are selected to be processed and stored on the spacecraft tape recorder for playback as "dump" telemetry. These are every tenth word, beginning with word No. 4 of each master frame. Each of these is in a subcommutated or sub-subcommutated data channel, with the exception of the sync words. Since only one-tenth of the master frame words comprise these data (called prime subframe data), the information bit rate as recorded on the tape recorder is one-tenth of the real-time telemetry bit rate, or 5.12K bps.

Since all prime subframe data words of the master frame are subcommutated at a ratio of 4:1 (or a multiple thereof), the prime subframe appears as a 64-word frame, repeated at the rate of 10 frames per second. The "dump" data received by ground stations are played back in reverse at 22 times its recorded 5.12K bps rate. This produces a "dump" bit rate of 112.64K bps.

n. Agena Format. The format used for Agena telemetry will be based on a main frame made up of 128 words of 8 bits each. Sixteen of these main frames are transmitted every second, producing an output rate of 16.384K bps. Agena TLM capability and channel utilization are illustrated in Tables 4.2-5 and 4.2-6.

Subcommutation is employed as indicated in Figure 4.2-7. Main frame word Nos. 17, 18 and 19 are combined to form a 24-bit word, which are then subcommutated at a ratio of 80:1, giving one 24-bit sample every 5 seconds.

Table 4.2-5 Agena Telemetry System Capability

Equipment and Rate	Specification
System	PCM/FM
Data Rate	16.384K bps, real-time data 65.536K bps, stored data
Sampling Rate Voltage Inputs Memory RO	Main Frame, 128 channels, 16 frames per second Subframe A, 128 channels, 1 subframe per second Subframe B, 80 channels, 1/5 subframe per second
Direct digital and pulse analog	Subframe C, 16 channels, 1 subframe per second
Tape Recorder	Record main frame on command, 20 minutes maximum capacity Readout on command, 5 minutes maximum capacity

Table 4.2-6 Agena Telemetry System Channel Utilization

Inputs	Channel Utilization
A. 128-Channel Multiplexer*	
Voltage analog data and calibration voltages	110
Command acceptance pulse	3
Direct digital and pulse analog data	1
Programmer memory readout	3
Main frame sync word (24 bits)	13
Submultiplexer	8
B. 128-Channel Submultiplexer**	
Analog data and calibration voltages	126
Sync word (16 bits)	2

* 16 sps/channel
** 1 sps/channel

These subcommutated data comprise subframe "B". Word No. 124 is subcommutated at a ratio of 16:1, giving one sample every 16 main frames, or one sample per second. Subframe "A" utilizes a combined supercommutation and subcommutation scheme which is best understood by consulting Figure 4.2-7.

4.2.3 Apollo Configuration

(To be supplied later.)

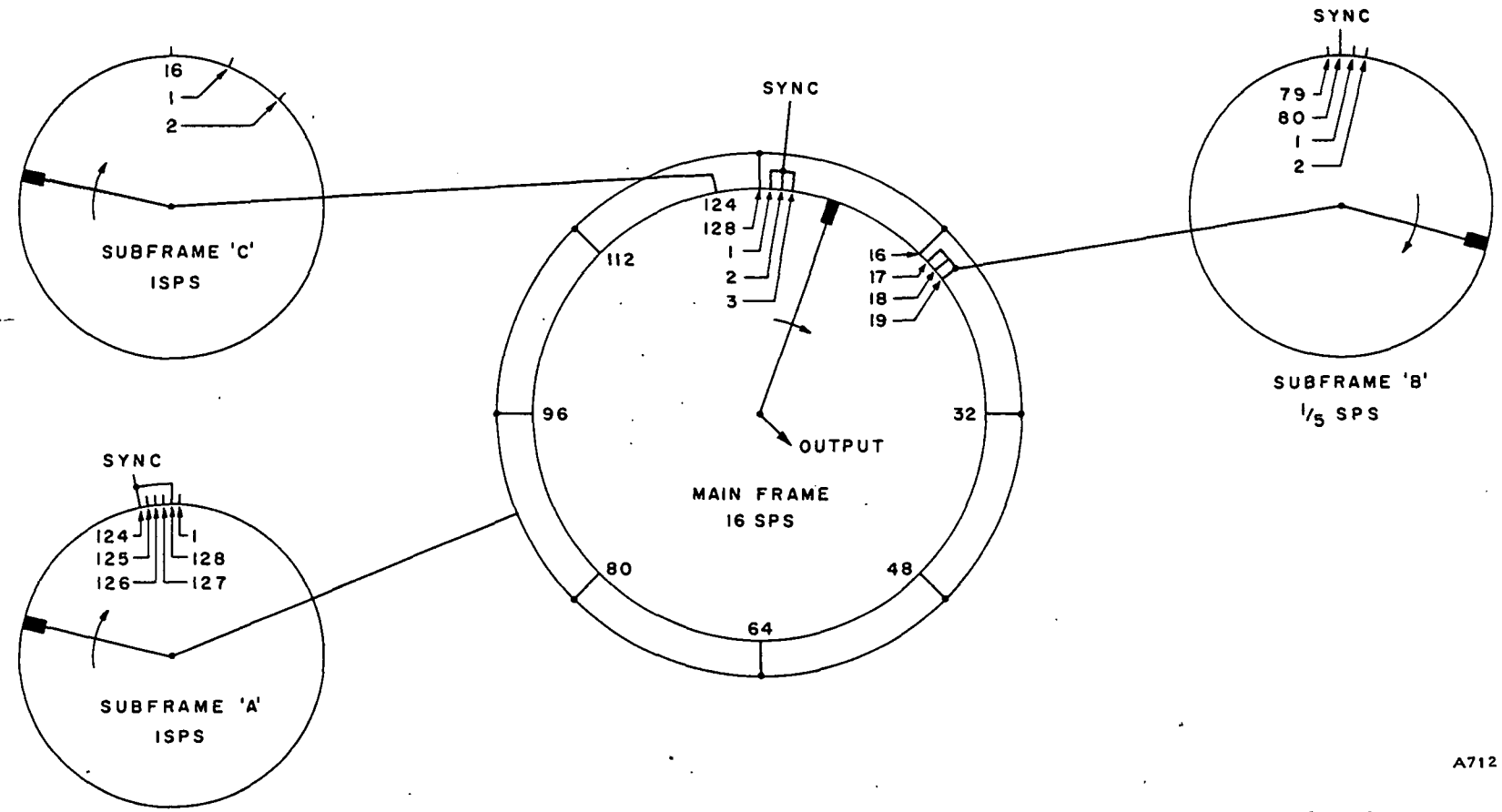


Figure 4.2-7 Mechanical Analog of the Subcommutation Format of the Agena Telemetry Multiplexer

4.3 GOSS DIGITAL COMMAND SYSTEM NETWORK

4.3.1 Sources of Information

The primary sources of information used for the compilation of data given in this section are as follows:

a. "GOSS Digital Command Network Data Book", 3 vols, PHO-TR122.

b. "Program Instrumentation Requirements Document (PIRD)--Project Gemini", NASA/MSC.

c. "Maintenance and Operations of the Digital Command System", Radiation, Inc.

d. "GOSS Communications Network Data Book", vols 3 and 4, PHO-1Z1000.

4.3.2 General Description

The GOSS Digital Command System Network (Figure 4.3-1) comprises all ground-based elements necessary for the generation, processing and transmission of digital data commands to a space vehicle or simulated space vehicle. The RTCC is the primary originator of commands, and delivers input data to the Communications Processor for buffering into the MDCS Units, the Remote Site DCS Units or the simulation equipment. Real-Time Sites are operated directly from the MDCS Units.

Redundant MDCS Units, under control of Flight Controllers during a mission or simulation exercise, may be used in several configurations for maximum utilization and dual operational requirements.

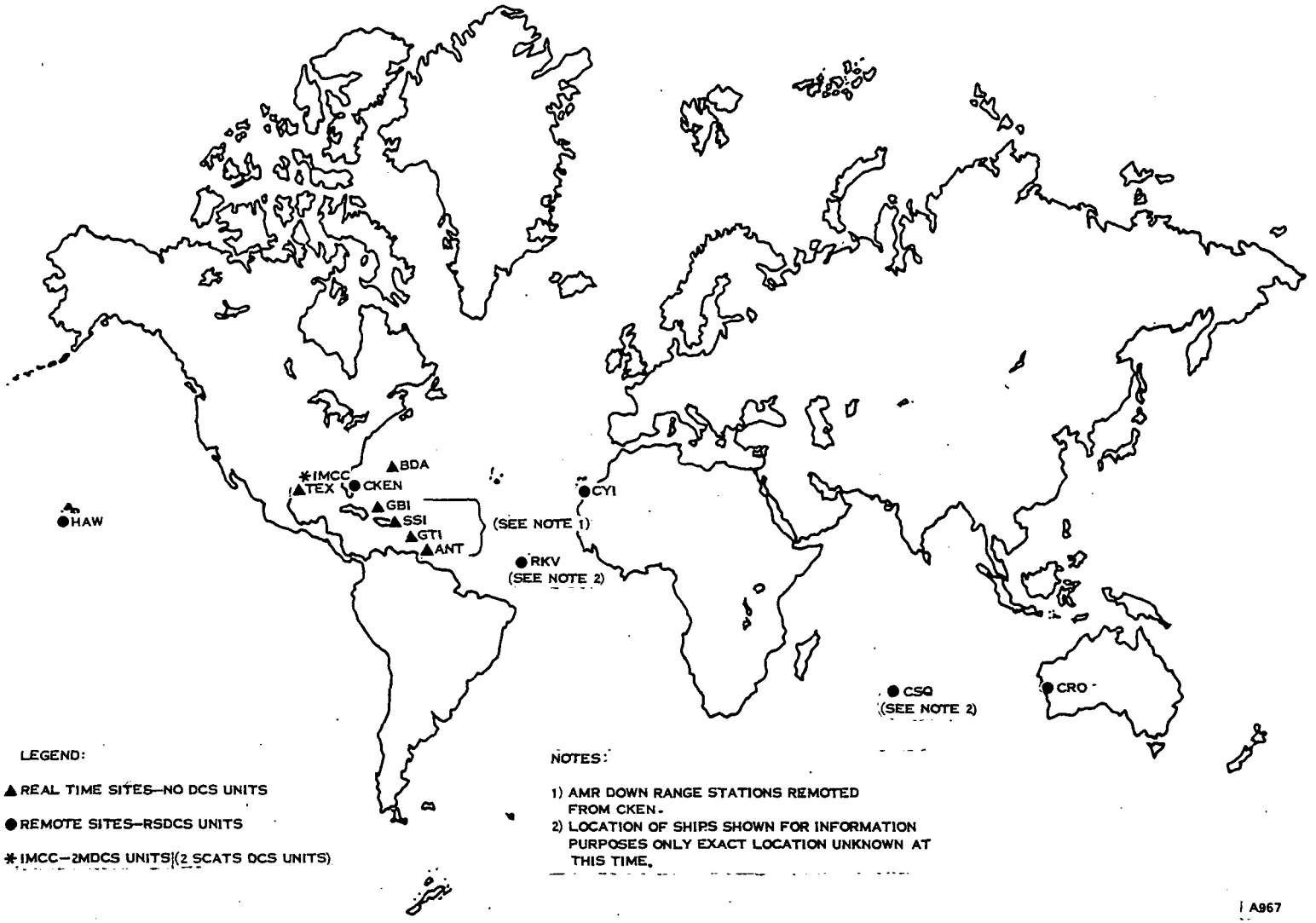


Figure 4.3-1 Digital Command System Network

The Remote Sites are equipped with an on-site DCS unit which performs the same function at the remote site that the MDCS performs at the Real-Time Sites, i.e., command data may be originated on-site. However, in all cases, primary command information for the Remote Sites will be received from the IMCC over teletype lines.

4.3.3 Gemini Configuration

The GOSS Digital Command Network will support Rendezvous and Non-Rendezvous Missions beginning with Project Gemini. The early ones will be Non-Rendezvous Missions and will be controlled from the CKEN/MCC. Prior to the IMCC becoming operational, the DCS at CKEN will act as the MDCS for these Non-Rendezvous Missions. During these missions it is not planned to orbit the Agena vehicle.

Figure 4.3-2 is a diagram of the Non-Rendezvous Network. Table 4.3-1 lists the Non-Rendezvous Network equipment for the Digital Command System, and Table 4.3-2 lists the Rendezvous Network equipment.

The Gemini Computer Word (CW) and the Agena Stored Program Commands (SPC) are being continuously computed in the RTCC, and, upon request from the MOCR, are sent to the Communications Processor at the rate of 40.8K bps. The format for this transfer is shown in Figure 4.3-3.

Table 4.3-1 Non-Rendezvous Network Equipment for Digital Command System

Site \ Equipment	MDCS	DCS Unit	Remote Xmit Interface		10 kw RF		Steer. Ant.	Trainer Interface
			DRED	DRUL	AN/FRW-2	240-D2		DRED
Cape Kennedy	1*	1	1	1	2	2	1	1
Grand Bahama Island**				1	2	2		
San Salvador Island**				1	2	2	1	
Grand Turk Island**				1	2	2		
Antigua Island**				1	2	2	1	
Bermuda**				1	2	2	1	
Canary Island		1			2	2	1	
Carnarvon		1			2	2	1	
Hawaii		1			2	2		
Corpus Christi		1			2	2	1	
Rose Knot Victory		1			1	1	1	
Coastal Sentry Quebec		1			1	1	1	

* Standard DCS Modified for TTY Output and IGS Up-Date
** Remote Transmitter Site Only

Table 4.3-2 Rendezvous Network Equipment for Digital Command System

Site \ Equipment	MDCS	DCS Unit	Remote Xmit Interface		10 kw RF		Steer. Ant.	Trainer Interface
			DRED	DRUL	AN/FRW-2	240-D2		
Houston (IMCC)	2	2*						2
Cape Kennedy**		1	1	1	2	2	2	1
Grand Bahama Island**				1	2	2	1***	
San Salvador Island**				1	2	2	1***	
Grand Turk Island**				1	2	2	1***	
Antigua Island**				1	2	2	2	
Bermuda **				1	2	2	2	
Canary Island		1			2	2	2	
Carnarvon		1			2	2	2	
Hawaii		1			2	2	2	
Corpus Christi**				1	2	2	2	
Rose Knot Victory		1			2	2	2	
Coastal Sentry Quebec		1			2	2	2	

* SCATS Equipment
** Remote Transmitter Site Only
*** Information gained from Command-Control sources at AMR

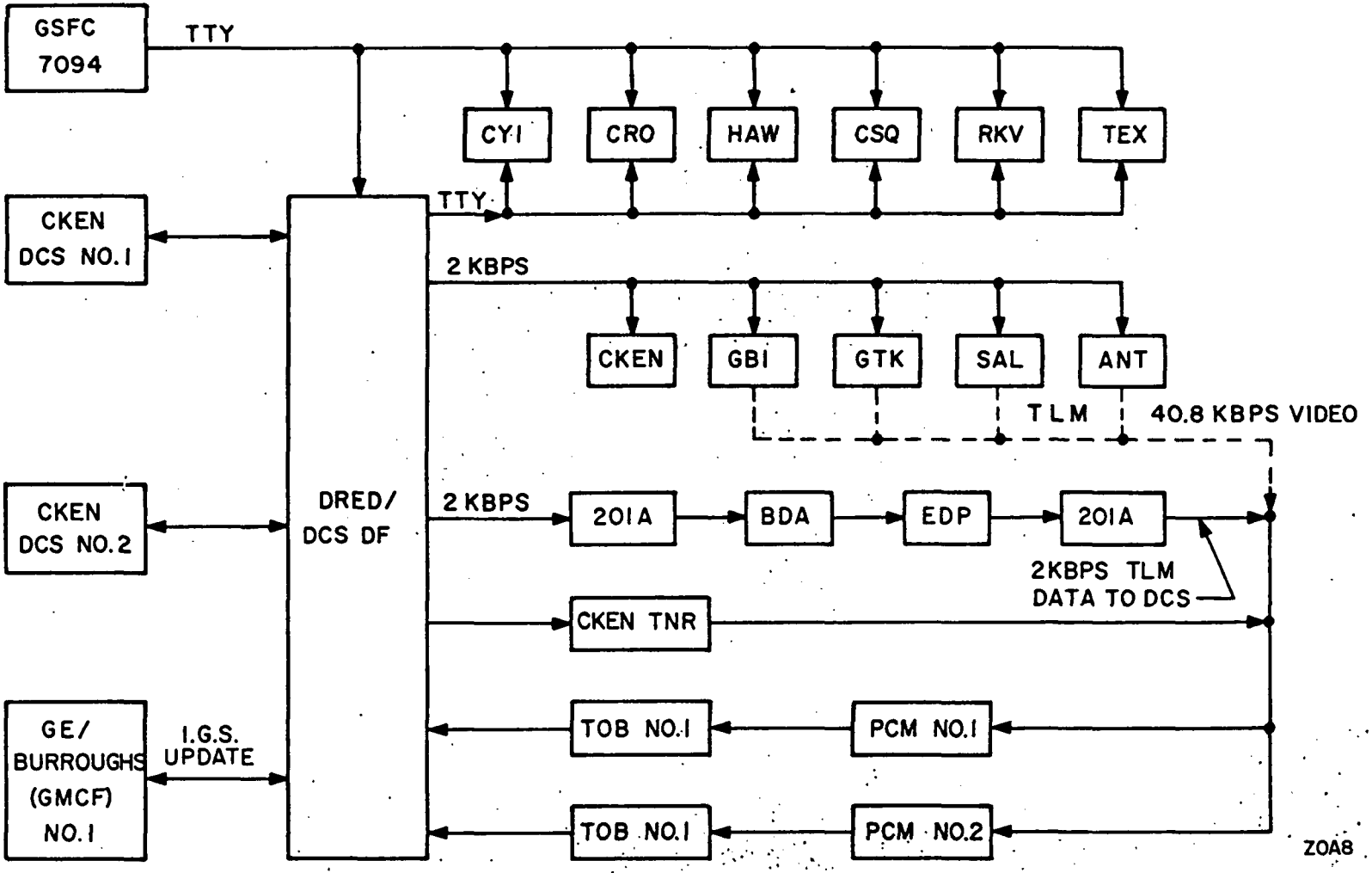


Figure 4.3-2 Gemini Non-Rendezvous Network

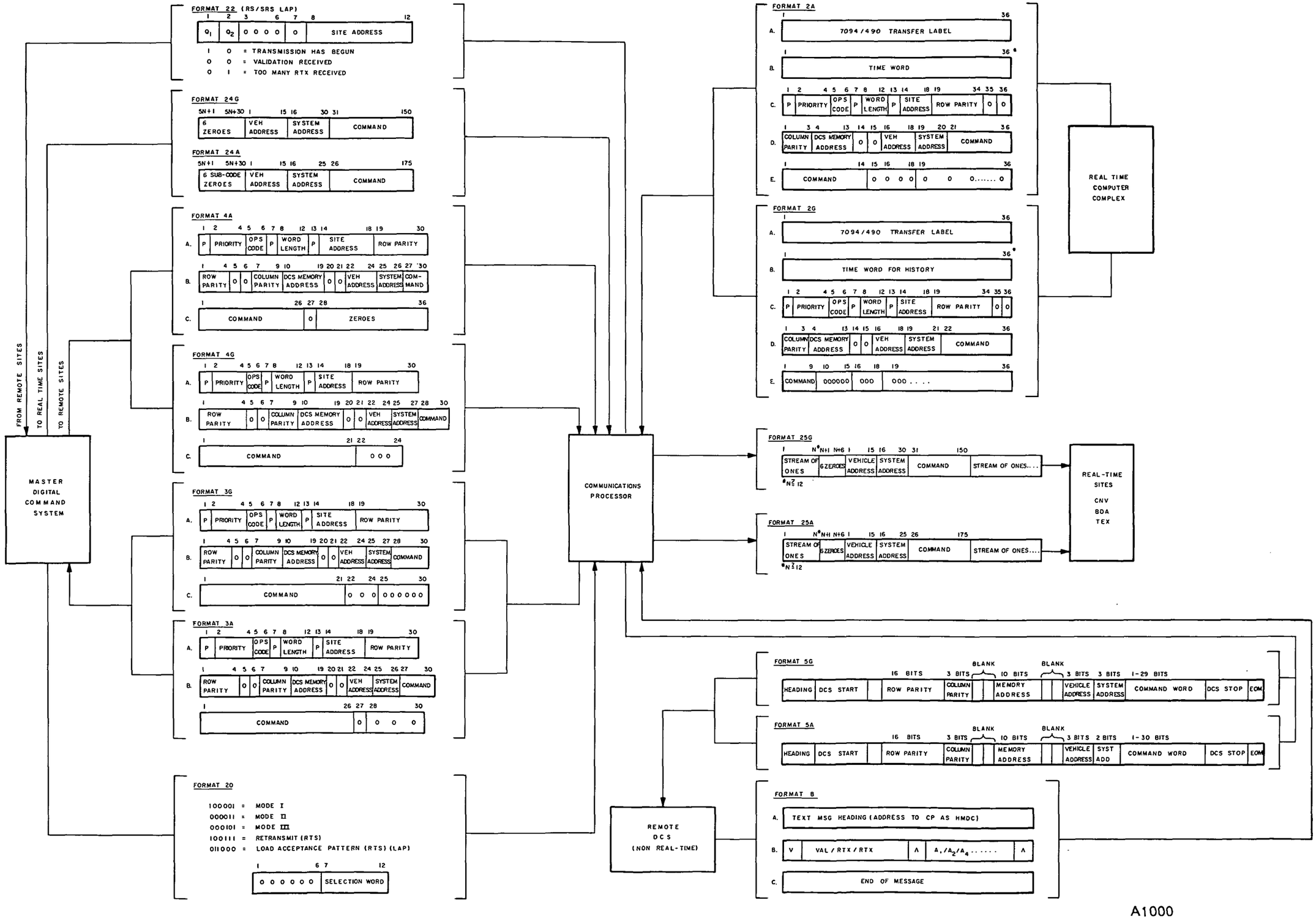


Figure 4.3-3 Operational Data Flow with Formats — Communications Processor Interfaces

4.3.3.1 Operational Modes

During a mission, the network may be operated in one of three modes which primarily affect the operation of the MDCS.

The operation functional flow diagrams of the three basic Gemini modes are shown in Figures 4.3-4, 4.3-5, and 4.3-6. These modes of operation for the transfer of TTY data to the Remote Site DCS Units are selectable from the MDCS console. When a mode has been selected, a 12-bit word is transferred from the MDCS to the Communications Processor to inform the Communications Processor how to route the command data. The operation of these modes, the formats, and data rates are discussed below.

a. Mode 1. In Mode 1 operation, the Communications Processor recognizes the transfer label as command information and buffers it into the proper TTY format and bit-rate, and routes it into the Termination Subsystem. From the Termination Subsystem, the command data are delivered to TELCO facilities for transmission to the proper site. The data are received on a priority interrupt at the site and are routed into the Remote Site DCS for verification and storage.

When the load has been received at the Remote Site, a message is returned to the IMCC indicating the condition of the received load. If all commands are received and verified, a Load Acceptance Pattern (LAP) is returned or a request is made to retransmit all or part of the load.

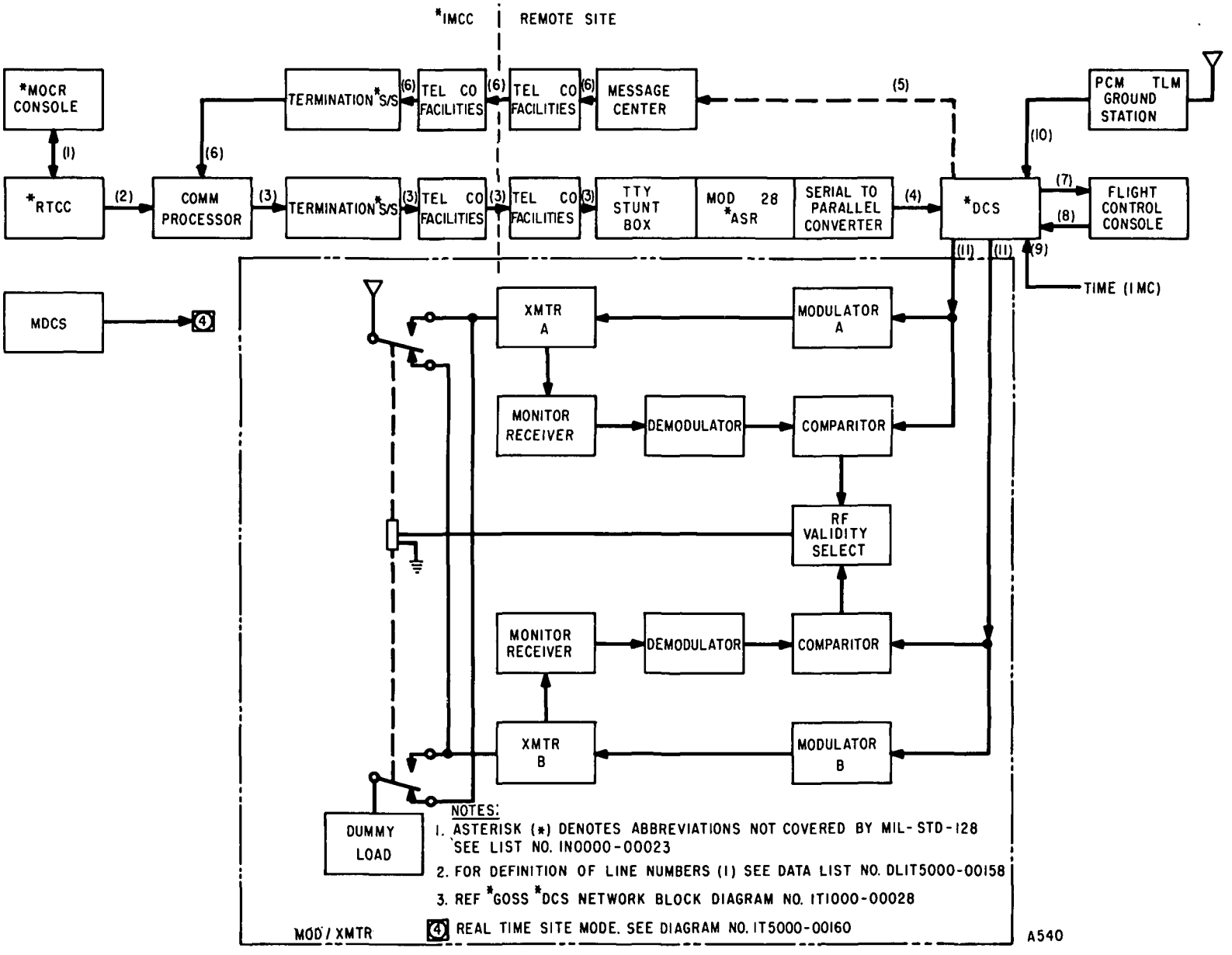
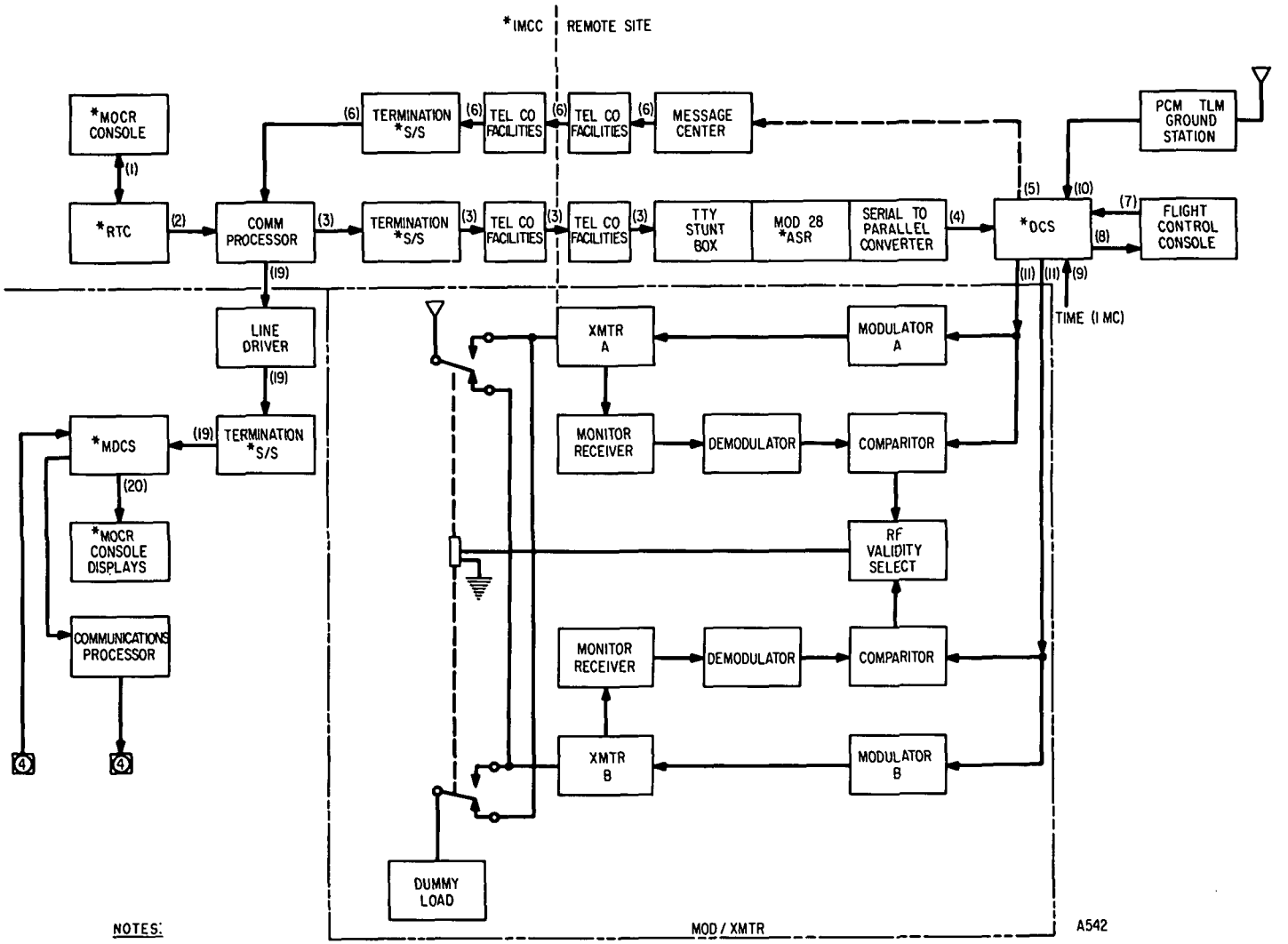


Figure 4.3-4 Operational Mode 1



NOTES:

1. ASTERISK (*) DENOTES ABBREVIATIONS NOT COVERED BY MIL-STD-128. SEE LIST NO. IN0000-00023.
2. FOR DEFINITIONS OF LINE NUMBERS (1) SEE DATA LIST NO. DL IT 5000-00159.
3. REF *GOSS *DCS NETWORK BLOCK DIAGRAM NO. IT 1000-00028.
4. REAL TIME SITE MODE. SEE DIAGRAM NO. IT 5000-00160.

Figure 4.3-5 Operational Mode 2

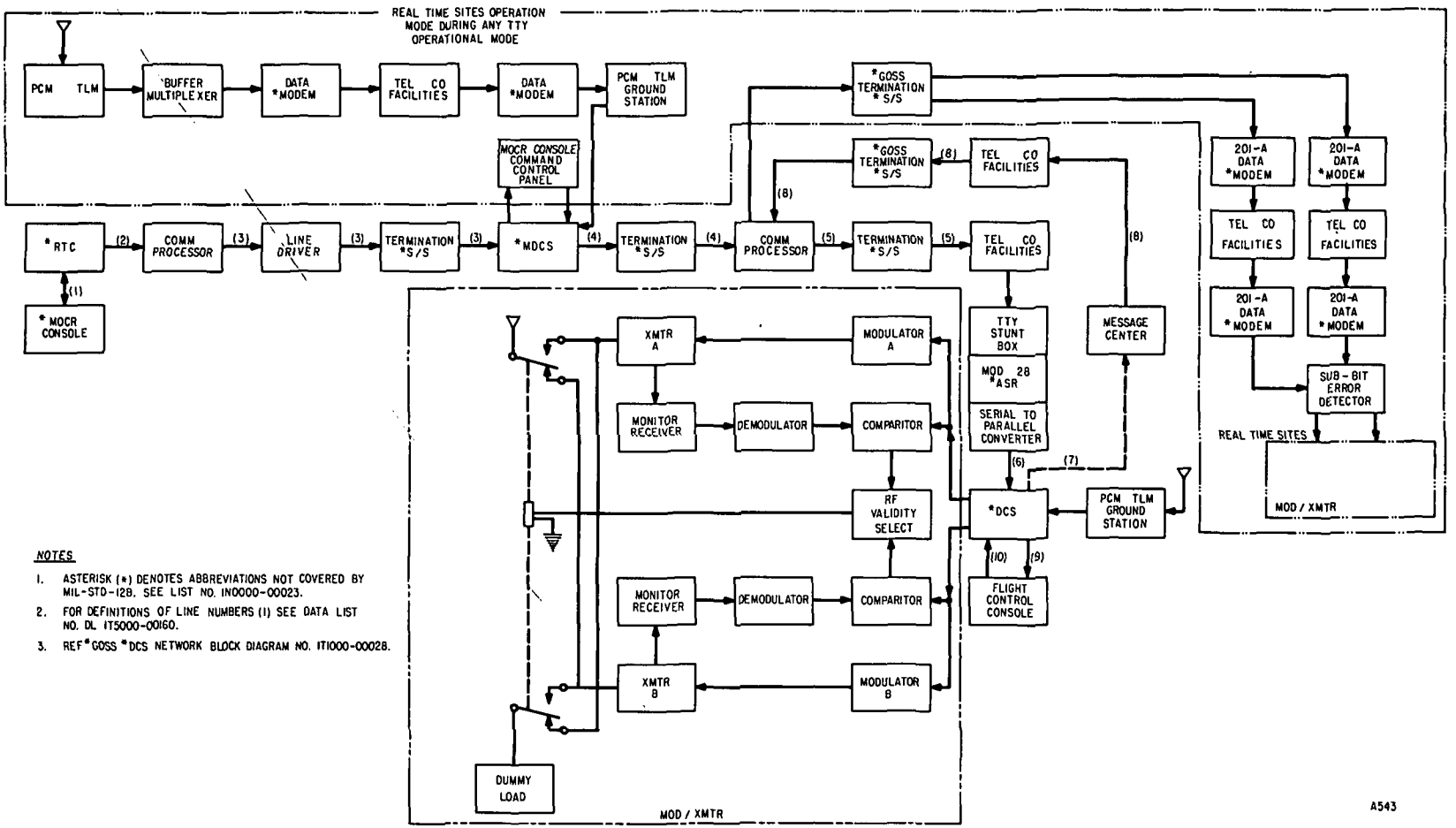


Figure 4.3-6 Operational Mode 3

The on-site Flight Controllers are notified by an indicator light on the Capsule Communications Console that the DCS is loaded and is ready for up-linking. Under the control of Flight Controllers, the commands are up-linked through the on-site command transmitters. The Remote Site DCS receives a Message Acceptance Pulse (MAP) after each command is transmitted, which permits the DCS to send the next command word. Due to the processing time within the spacecraft, the DCS has a waiting period between the transmission of a command and the reception of a MAP. This waiting period varies between 25 ms and 300 ms in 25 ms increments. If the DCS has not received a MAP within the selected waiting period, it can be programmed to retransmit the same word up to 7 times. A priority command will be retransmitted continuously until operator intervention.

Commands may be sent from one of the Real-Time Sites, utilizing the MDCS units, in this mode of operation (discussed under Mode 3, below).

b. Mode 2. If Mode 2 is selected at the MDCS, the functional flow is identical to Mode 1 with the addition of a parallel output from the Communications Processor to the MDCS. The command load which is sent to the Remote Site is also put into storage in the MDCS.

c. Mode 3. The most flexible operation is afforded by the selection of Mode 3. The computed data are sent from the RTCC through the Communications Processor and Termination Subsystem as in Mode 1, but they are routed to the MDCS and put into storage at the rate of 1K bps. The Real-Time

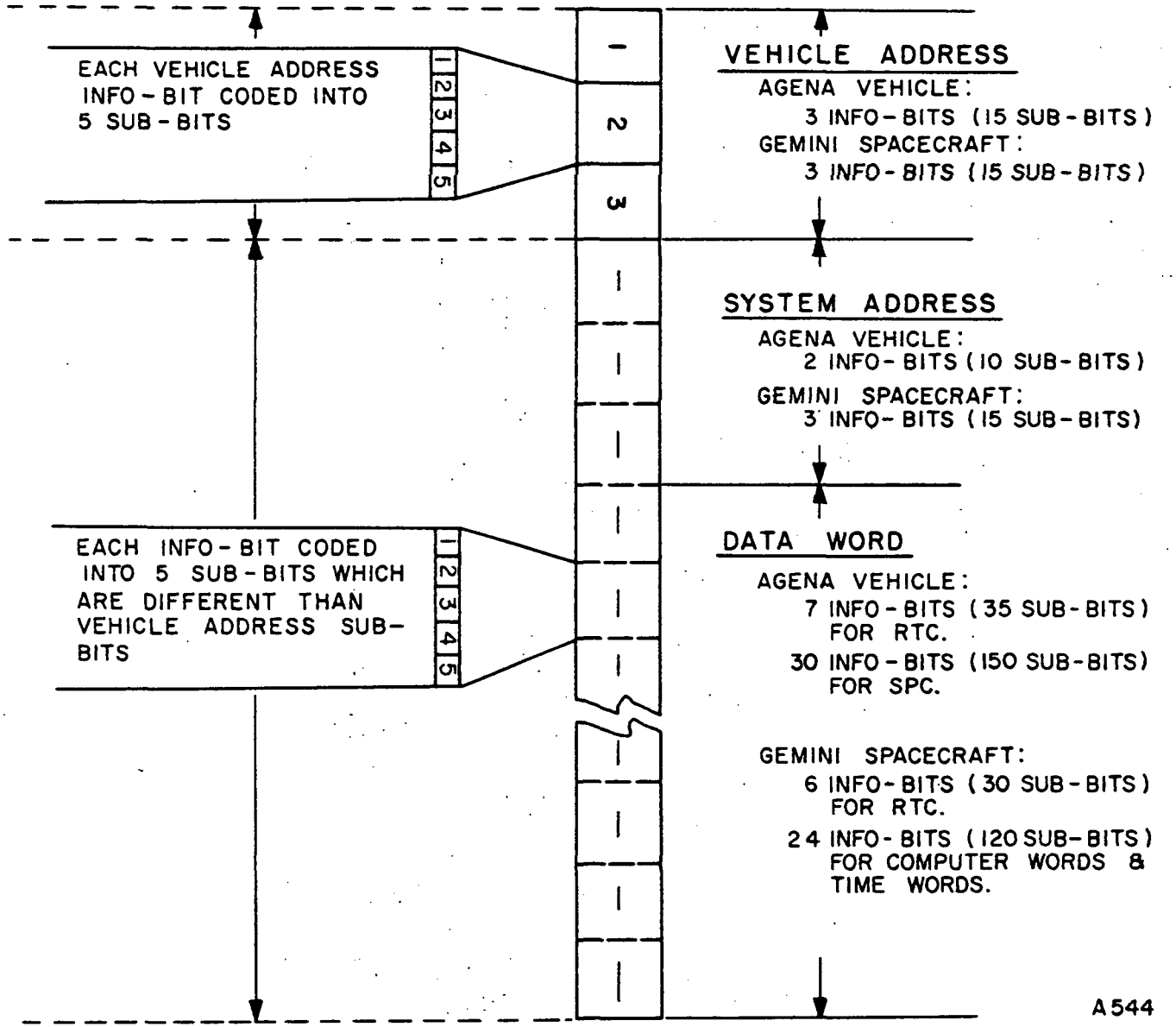


Figure 4.3-7 Digital Command System Subbit Format

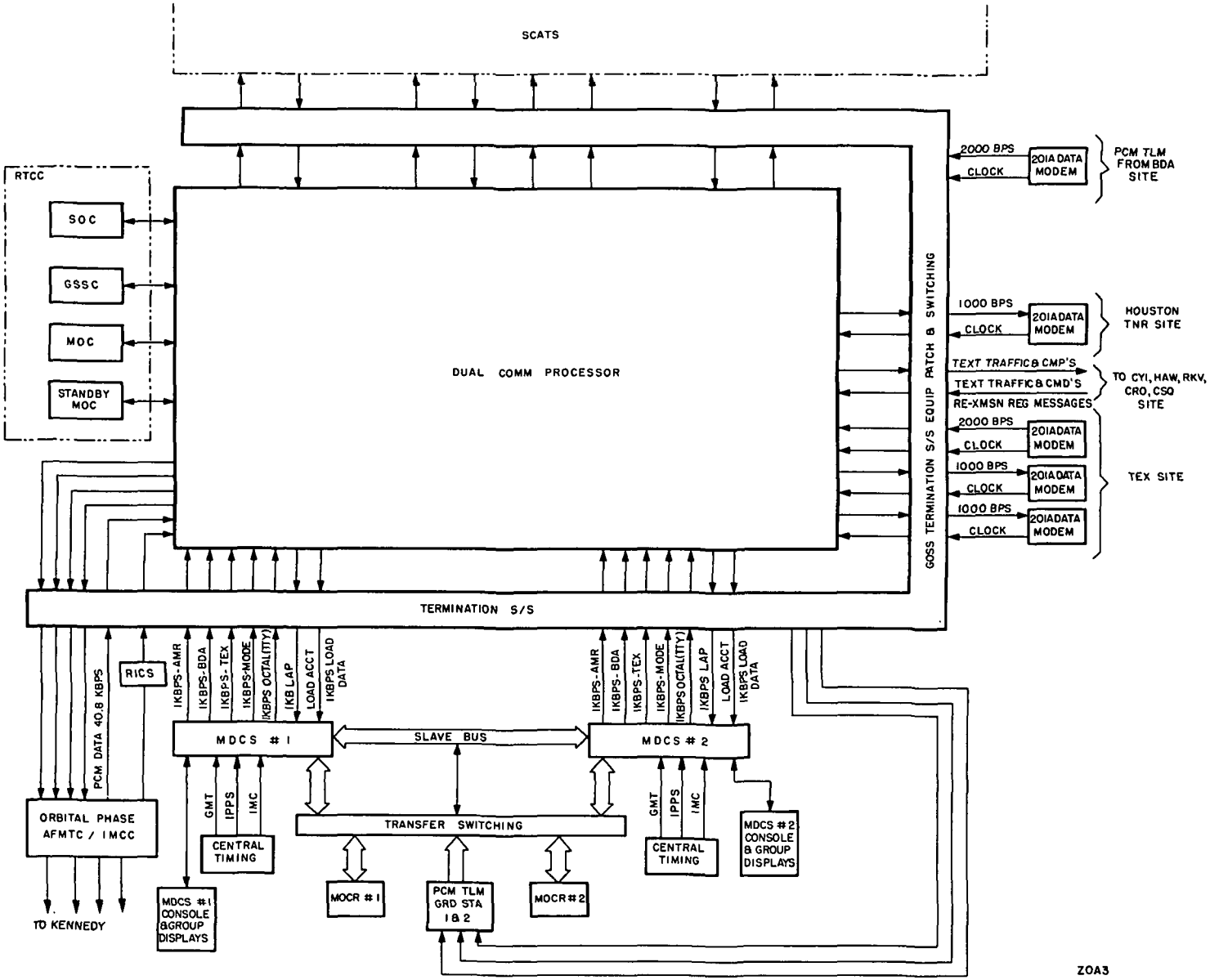


Figure 4.3-8 Block Diagram of the Digital Command System Functional Flow Within the Integrated Mission Control Center

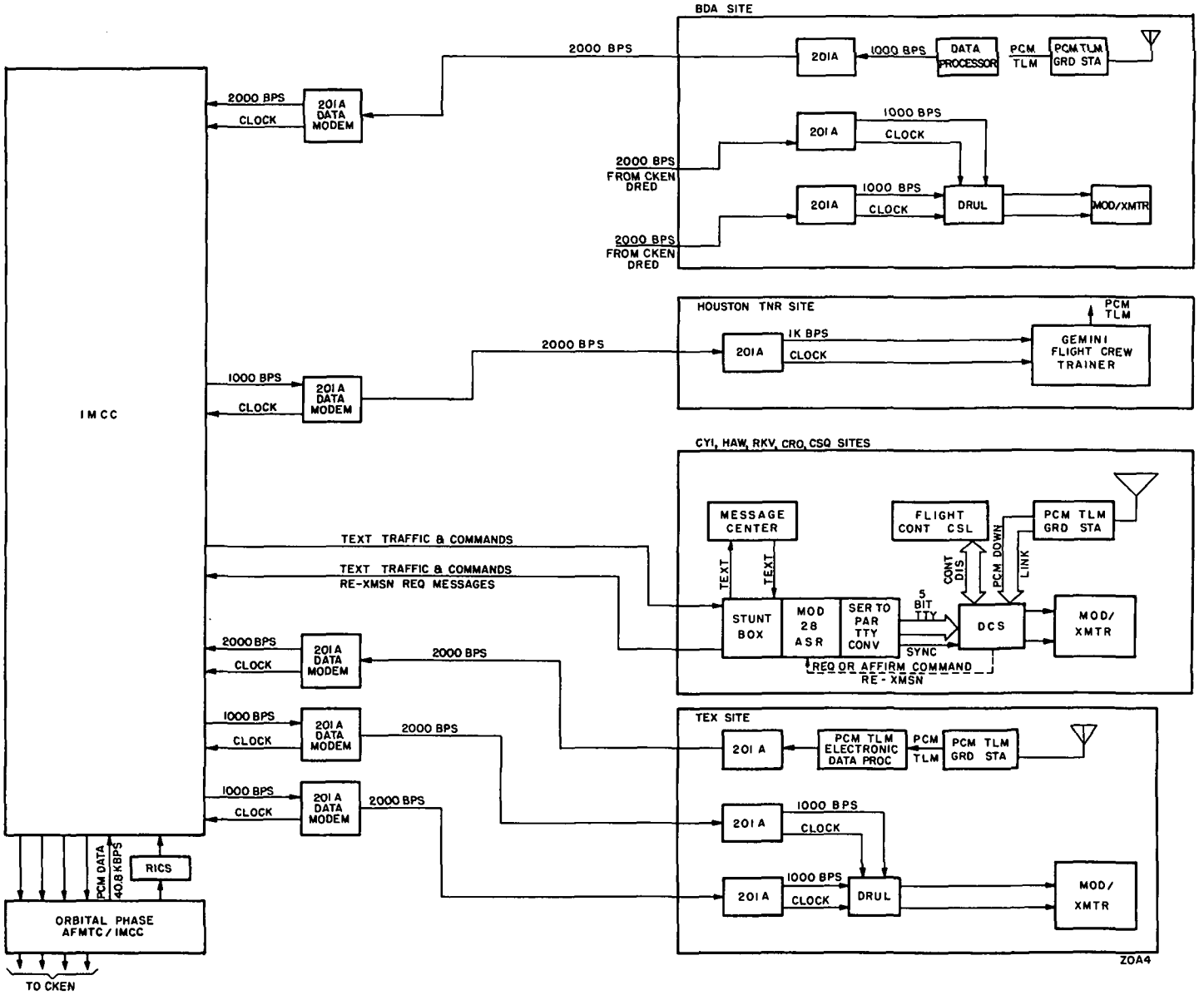


Figure 4.3-9 Block Diagram of the Digital Command System Functional Flow for Data Arriving at Real Time and Remote Sites

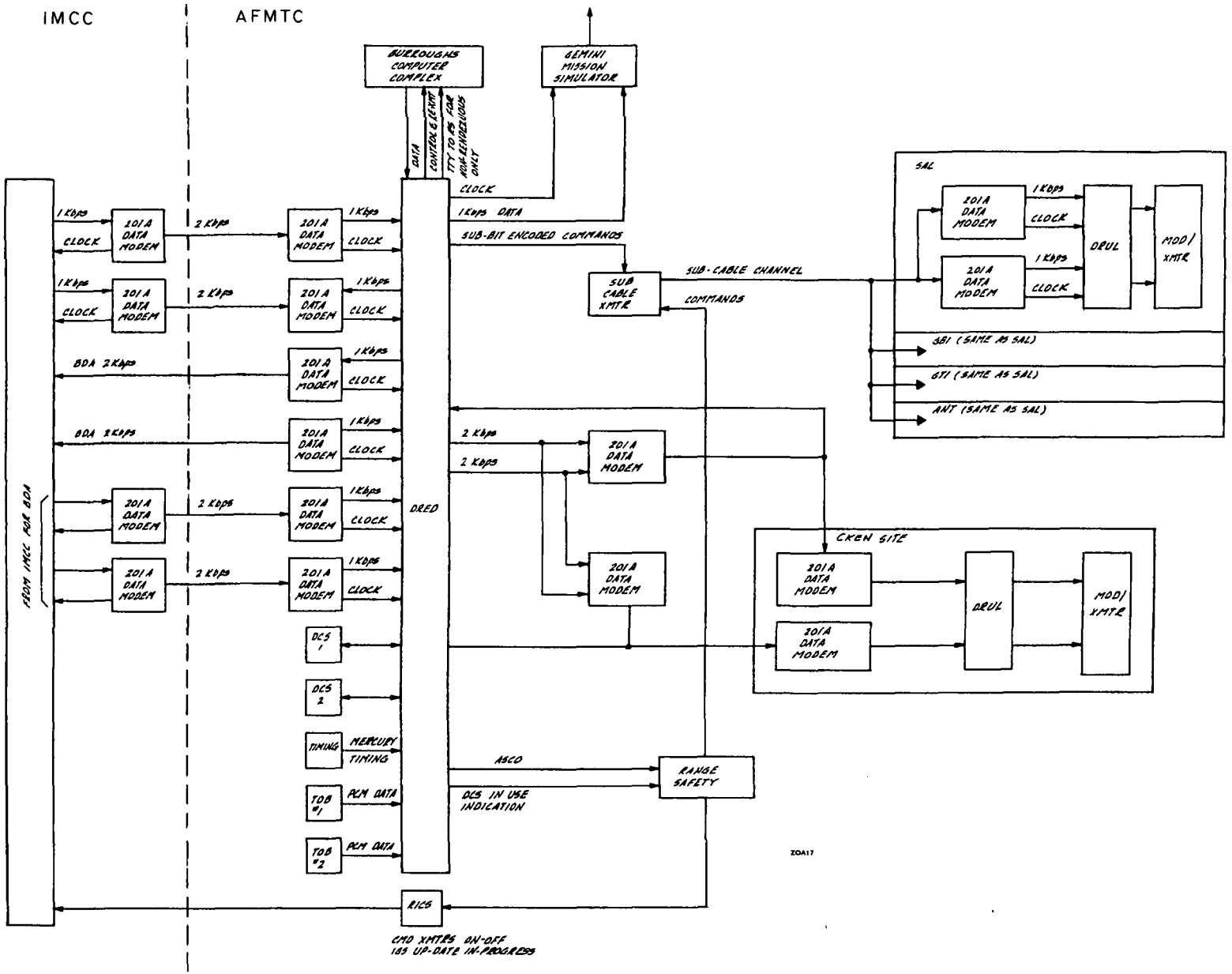


Figure 4.3-10 Block Diagram of the Functional Flow for Data Arriving at the Cape Kennedy, Bermuda and Atlantic Missile Range Downrange Sites

Commands are manually placed in storage before the mission and the RTCC generated commands are stored before the pass.

At the discretion of the Flight Controllers, a particular Remote Site may be loaded from the MDCS storage. The MDCS unloads the commands for the Remote Site, at the rate of 1K bps, into the Communications Processor, which effects the bit-rate change and recognizes routing information. From this point the transfer of data is the same as Mode 1.

The block diagram of the DCS functional flow within the IMCC, and up to transmission to the Remote Sites or Real-Time Sites, is given in Figure 4.3-8. The flow of commands will be the same regardless of which mode is selected.

Figure 4.3-9 shows the major equipment interfaces and the DCS functional flow of data arriving at Real-Time Sites and Remote Sites. Figure 4.3-10 shows the functional flow of data arriving at Cape Kennedy, Bermuda, and the AMR downrange sites.

4.3.3.2 DCS Non-Rendezvous Missions.

The early non-rendezvous Gemini flights will be controlled from the CKEN/MCC, by the Flight Controllers at the CKEN/MCC through use of a modified DCS Unit.

Figure 4.3-2 shows the Gemini Non-Rendezvous Network. Prior to installation of the RTCC and the IMCC becoming operational, all commands will be computed by the GSFC operational computers.

The GSFC computers transmit commands via teletype directly to the Remote Site DCS Units located at CYI, CRO, HAW, CSQ, RKV, TEX, and to the DCS Units at CKEN.

Commands coming from the GSFC to CKEN are routed through the Data Router and Error Detector (DRED) Unit to the DCS Units for storage. Upon initiation by the Flight Controllers, commands are transmitted at the rate of 1K bps to the AMR downrange and Bermuda stations. The data are received at these stations in Downrange-Up-Link (DRUL) Units. (These stations do not have DCS Units.) The DRUL Units synchronize the data and produce the PSK modulation. The data are then sent to the AN/FRW-2 transmitters for uplinking to the spacecraft. Upon receipt of a valid command by the spacecraft, a Message Acceptance Pulse (MAP) is transmitted, through the PCM TLM ground stations, back to the DCS Units at CKEN. This allows the DCS Units to send the next command word. If the DCS has not received a MAP within a selected waiting period, it can be programmed to retransmit the same word up to seven times. A priority command will be continuously retransmitted until operator intervention.

4.3.3.3 DCS Rendezvous Missions

The functional flow of digital commands within the IMCC has been discussed in the preceding paragraphs. This section will discuss the functional flow of commands from the IMCC to the various network stations located round the world.

Commands leaving the IMCC for the sites are transmitted in various modes. Real-Time Sites receive data, via HSD lines at 1000 bps and Remote Sites receive their data via teletype on LSD lines.

The AMR, Bermuda and Texas sites are considered real-time active sites and do not have Remote Site DCS Units. Data being transmitted to BDA and TEX come in over redundant HSD lines at 1000 bps to the TELCO 201A Data Modems (even though they operate at 2K bps). The data are then transmitted from the 201A Data Modems at 1000 bps to the DRUL Units. The DRUL Units provide sub-bit error detection, bit synchronization, word synchronization and produce PSK modulation. Data are then transmitted to the AN/FRW-2 transmitters for up-linking to the spacecraft.

Command data coming from the IMCC to CKEN are transmitted over HSD lines at 1000 bps. The data are received at CKEN in the Data Routing and Error Detection (DRED) Unit. The DRED Unit provides data routing, sub-bit error detection, bit synchronization, and word synchronization. The commands are then routed to the particular CKEN or downrange AMR stations for up-linking to the spacecraft.

Command data transmitted to the remote sites which have DCS units, receive the data via teletype on LSD lines. At this time the following Remote Sites have a DCS capability: Canary Island, Hawaii, Carnarvon, Rose Knot Victory and Coastal Sentry Quebec. Command data coming into these sites are received in a "stunt box" which differentiates between a regular text message and a Digital Command message. A DCS command is forwarded to the 28 ASR teletype machine and in parallel to the message center. From the 28 ASR the data are sent to the Remote Site DCS Unit for storage. Also real-time commands may be manually loaded into the Remote Site DCS Units. The Remote Site DCS Unit will affirm receipt of a DCS command, or if an error is detected in the command message the operator may request a re-transmission of the command.

4.3.3.4 Command Types

All commands to the Gemini and Agena vehicles will consist of messages which are sub-bit encoded. Each information bit is transmitted as a 5-bit pattern. For example, the sub-bit pattern of 10011 could represent a logical ONE, and the sub-bit pattern of 01100 could represent a logical ZERO. Any other pattern of sub-bits would be rejected as a bad transmission and the data word would be rejected. Figure 4.3-7 shows the sub-bit encoding in pictorial form.

The types of commands, according to function, for the Gemini/Agena mission are as follows:

- Real-Time Commands (RTC)
- Stored Program Commands (SPC)
- Computer Words (CW)
- Time Words.

a. Agena Commands. The Agena DCS provides the means of receiving encoded digital commands which have been transmitted from the ground stations. These commands may be executed in real-time or at subsequent time, as determined by the message time labels.

The vehicle DCS recognizes the receipt of a valid ONE or ZERO information-bit code (of the Vehicle Address) as a start of a command message. (The sub-bit coding of the vehicle address is different from the command function sub-bit coding.)

The Agena DCS also recognizes the receipt of at least three information bits (15 sub-bits) of ONE's or ZERO's as the end of message. The system will accept as valid those commands which have the correct vehicle address, a valid system address, and the correct message length followed by the end-of-message bits. Any message in which a sub-bit code error occurs will immediately be interrupted, because it will not meet the above criteria. For messages which are accepted, a message acceptance signal (+5 VDC) is sent to the PCM TLM for transmission down-link as the MAP.

(1) Real-Time Commands. The Real-Time Commands consist of commands which are delivered to the vehicle subsystems as 2-state functions. The output devices are electro-mechanical relays or bi-level electronic switches. Agena real-time command messages consist of a vehicle address, a system address, and a command function word. These commands are described below, and are exemplified by such commands as "antenna transfer" and "guide light on".

- Vehicle Address. The Vehicle Address consists of three information bits (bits 1-3). The information bits are arranged for recognition by the specific vehicle.
- System Address. The System Address consists of two information bits (bits 4-5), and identifies the message as an RTC or SPC.
- Command Function Word. The Agena Computer function words are made up of seven information bits (bits 6-12) which permit selection of any of the 128 possible discrete-command functions. However, there will be a hardware limitation of 94 discrete outputs.

(2) Stored Program Commands. The Agena Stored Program Command (SPC) functions are similar to the RTC, but are executed at a future time. The formats are different, however, since the command word must contain additional information. The Agena DCS is capable of retaining 64 stored program commands at one time.

The SPC's consist of a vehicle address, a system address, a command function word, a time label, and a row address.

The function of each portion is described below.

- Vehicle Address. The Vehicle Address consists of three information bits (bits 1-3). The information bits are arranged for recognition by the specific vehicle.
- System Address. The System Address consists of two information bits (bits 4-5), and identifies the message as an RTC or SPC.
- Command Function Word. The Agena Computer function words are made up of seven information bits (bits 6-12) which permit selection of any of the 128 possible discrete-command functions. However, there will be a hardware limitation of 94 discrete outputs.
- Time Label. The Agena time label is a 17-bit (bits 13-29) binary coded word which uniquely specifies a one-second increment out of 131,071 seconds. At the specific second, the SPC will be executed.
- Row Select Word. The memory row select word consists of 6 bits (bits 30-35), and identifies any one of 64 rows for command function word (Command Function Word, above) and time label (Time Label, above) storage in the DCS memory.

(3) Command Actuation. The actuation of an Agena command consists of supplying an impulse to the appropriate output device. The devices are electro-mechanical relays and electronic switching devices.

b. Gemini Commands. The Gemini commands are sub-bit encoded within the ground DCS, and appear similar to the Agena sub-bits, but the coding is different. The sub-bit encoding is explained in Section 4.3.3.4.

The formats for the Gemini command messages are described as follows:

(1) Real-Time Commands. The Gemini DCS has 32 relays which are capable of being actuated selectively by 64 Gemini RTC's. These RTC's are comprised of 12 information bits and contain the following sub-command word information groups:

- Vehicle Address. The vehicle address consists of the first three information bits (bits 1-3). These are sub-bit encoded differently from the later portion of the command.
- System Address. The system address consists of three information bits (bits 4-6) which identify the message as follows: Real-Time Command (RTC), Computer Message (CM), or a Time Reference Message.
- Label. The Gemini label consists of five information bits (bits 7-11) which select the particular spacecraft system to be actuated.
- Data Words. The data word consists of a single information bit (bit 12) which determines if the selected system will be turned ON or OFF. The coding is arranged such that a ONE will turn the system ON, and a ZERO will turn the system OFF. For example, RTC Number 9 has a data word of ONE which turns ON the tape playback.

(2) Computer Message. The Gemini Spacecraft computer has the capability of accepting data from the ground transmitters via the on-board DCS. These up-link data will be used to update maneuver thrust calculations, fuel requirement calculations, and re-entry calculations. These data are called a computer message. The format for computer words is described as follows:

- Vehicle Address. The vehicle address consists of the first three information bits (bits 1-3). These are sub-bit encoded differently from the later portion of the command.
- System Address. The system address consists of three information bits (bits 4-6) which identify the message as follows: Real-Time Command (RTC), Computer Message (CM), or a Time Reference Message.
- Computer Address. The bits constituting the computer address determine the computer memory location where the particular message is stored. This address consists of six information bits (bits 7-12).
- Word Magnitude. The parameters which are updated by computer words are multi-level data. The intelligence must be more than an ON or OFF function. The word magnitude consists of 17 information bits (bits 13-29).
- Sign Word. The sign words determine if the quantity in the word magnitude is positive or negative. The sign information consists of a single bit (bit 30). When bit 30 appears as a ONE, the quantity is negative (-); and when bit 30 appears as a ZERO, the quantity is positive (+).

(3) Time Reference Message. The Gemini Spacecraft's electronic timer will receive data via the DCS up-link. These data are called time reference messages, and provide the

spacecraft with ground computed time "to go" to Retro-fire (T_r) and time "to go" to equipment reset (T_x). The time word format is described as follows:

- Vehicle Address Word. The vehicle address consists of the first three information bits (bits 1-3). These are sub-bit encoded differently from the later portion of the command.
- System Address Word. The system address consists of three information bits (bits 4-6) which identify the message as follows: Real-Time Command (RTC), Computer Message (CM), or a Time Reference Message.
- Data Word. The time reference data word consists of 16 information bits (bits 7-22) for T_x, and 24 informating bits (bits 7-30) for T_r. The least significant bit of the time messages represents 1/8 second.

(4) Message Verification. The Gemini DCS will emit a verification signal only if there is a positive validity check on the sub-bit coding of each information bit of the message, and, if decoding, buffer storage and data transfer have been correctly accomplished. The verification signal is +5 VDC, which is sent to PCM TLM for down-linking to the originating ground DCS.

(5) Command Actuation. Actuation of a Gemini DCS command is accomplished by actuating the appropriate RTC relay, or by transferring the data into the on-board computer or into the electronic timer.

The vehicle address, system address, and both the sub-bit codes for the Gemini Spacecraft are classified.

The various formats and data flow are shown in Figure 4.3-3.

4.4 GLOBAL COMMUNICATIONS NETWORK

4.4.1 Sources of Information

The primary sources of information used for the compilation of data given in this section are as follows:

a. "GOSS Communications Network Data Book," PHO-1Z1000, Vol. 1 and Vol. 2.

b. "Program Instrumentation Requirements Document (PIRD) - Project Gemini," NASA/MSC

c. "Program Instrumentation Requirements Document (PIRD) - Project Apollo," NASA/MSC

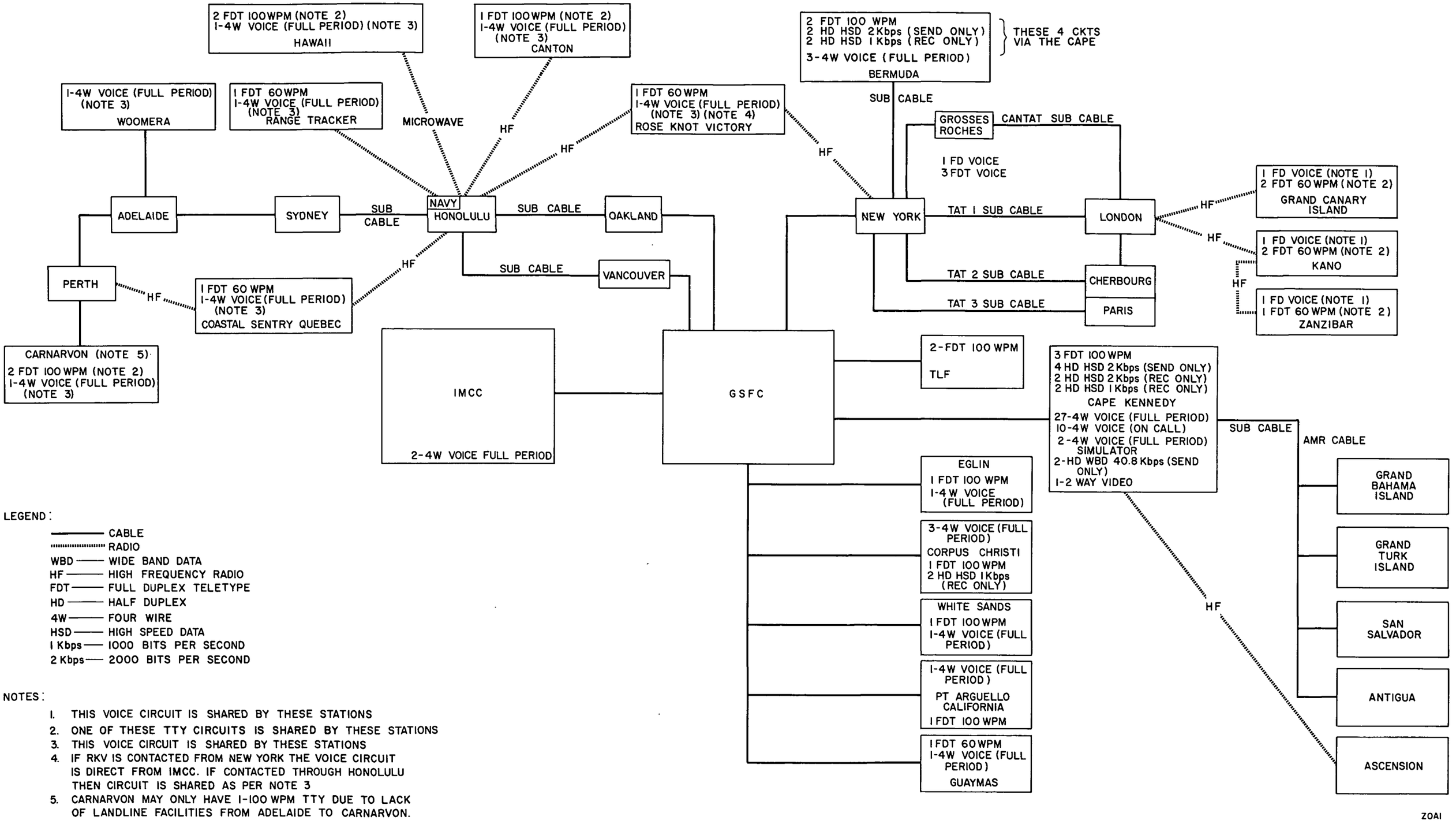
The NASA Global Communications Network is composed chiefly of leased commercial facilities. NASA operates switching centers at strategic locations to exercise efficient control of these leased facilities. The configuration of the network is therefore flexible and reflects the nature of the mission.

4.4.2 Gemini Network Configuration

Figures 4.4-1 and 4.4-2 show the network as currently projected for Gemini Pre-Rendezvous and Rendezvous Missions. Table 4.4-1 lists each circuit terminating in the IMCC and briefly describes its type and purpose.

4.4.3 Apollo Network Configuration

Figure 4.4-3 reflects Apollo network planning in accordance with Reference c, above. As further documentation becomes available, this section will be updated.



LEGEND:

- CABLE
- RADIO
- WBD — WIDE BAND DATA
- HF — HIGH FREQUENCY RADIO
- FDT — FULL DUPLEX TELETYPE
- HD — HALF DUPLEX
- 4W — FOUR WIRE
- HSD — HIGH SPEED DATA
- 1 Kbps — 1000 BITS PER SECOND
- 2 Kbps — 2000 BITS PER SECOND

NOTES:

1. THIS VOICE CIRCUIT IS SHARED BY THESE STATIONS
2. ONE OF THESE TTY CIRCUITS IS SHARED BY THESE STATIONS
3. THIS VOICE CIRCUIT IS SHARED BY THESE STATIONS
4. IF RKV IS CONTACTED FROM NEW YORK THE VOICE CIRCUIT IS DIRECT FROM IMCC. IF CONTACTED THROUGH HONOLULU THEN CIRCUIT IS SHARED AS PER NOTE 3
5. CARNARVON MAY ONLY HAVE 1-100 WPM TTY DUE TO LACK OF LANDLINE FACILITIES FROM ADELAIDE TO CARNARVON.

Figure 4.4-1 Gemini Pre-Rendezvous Network

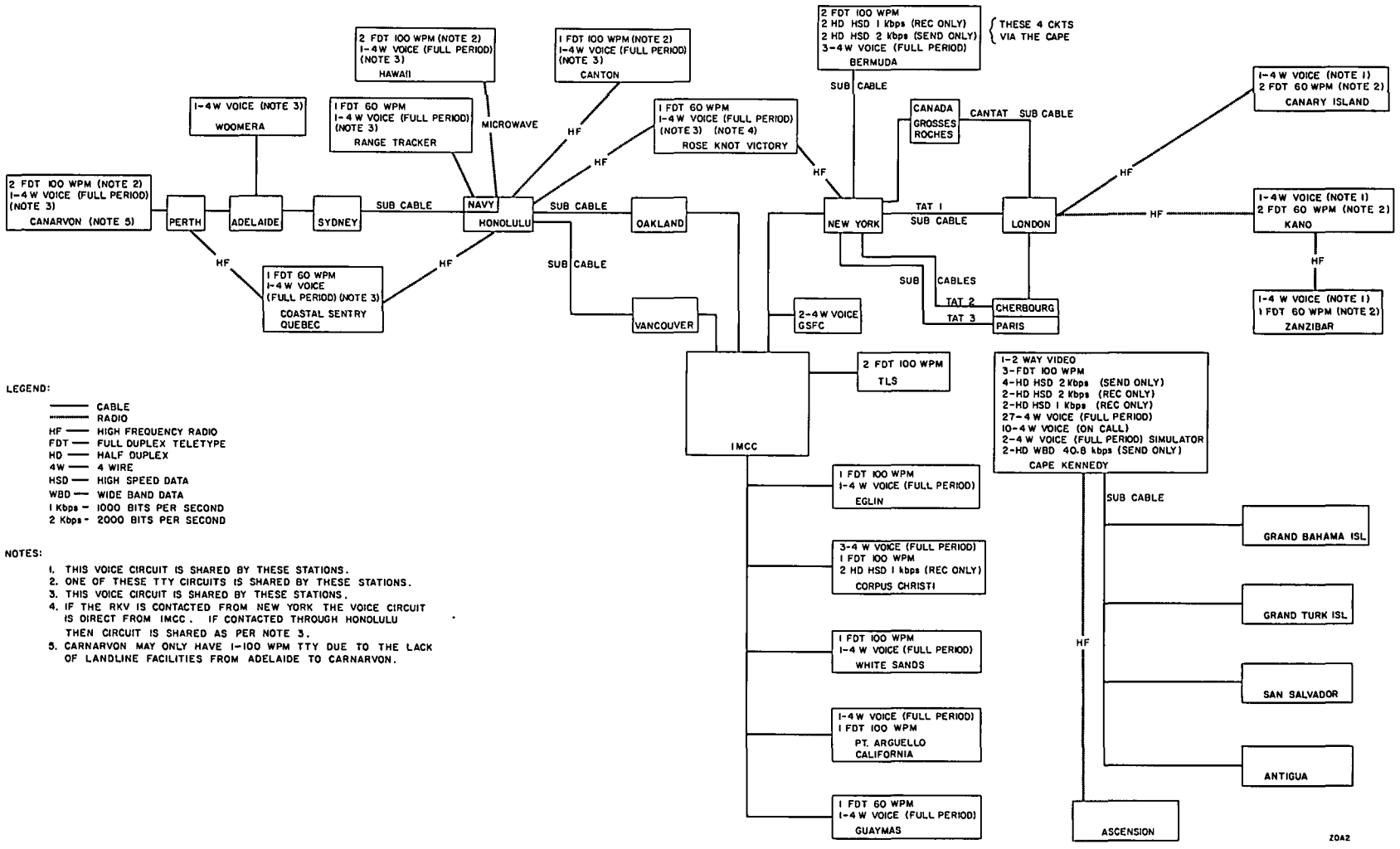


Figure 4.4-2 Gemini Rendezvous Network
(Pre-Apollo)

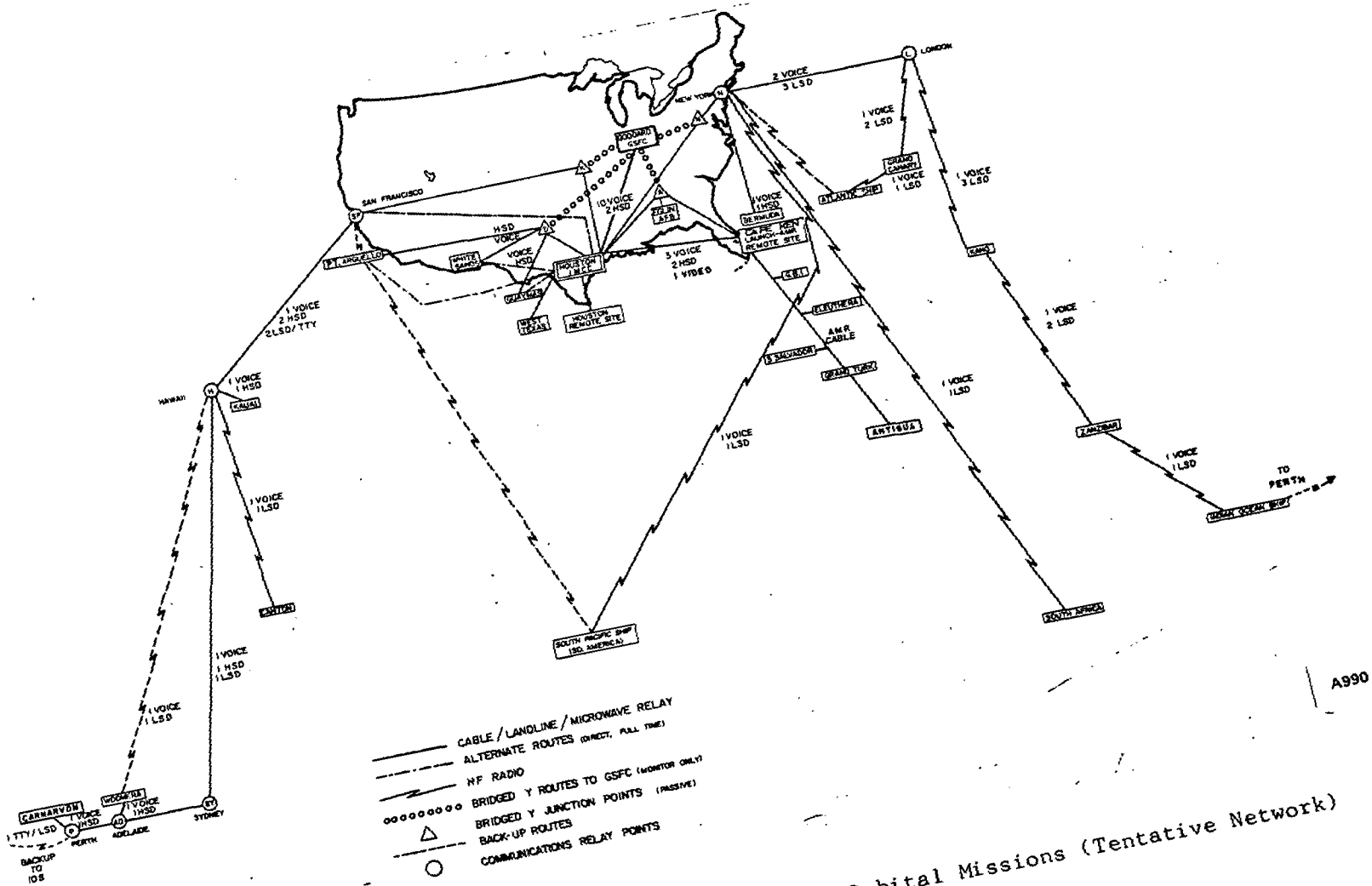


Figure 4.4-3 GOSS Communications Network for Apollo Orbital Missions (Tentative Network)

Table 4.4-1 Communications Lines for Gemini

SITE	VOICE	WBD	HSD	TTY	REMARKS
Cape Kennedy	35 FD	2 CKEN/IMCC 40.8K bps	4 CKEN/IMCC 6 IMCC/CKEN	3 FDT	WBD used for remoting spacecraft and booster telemetry from CKEN to IMCC. Additional line for real-time backup.
			2K bps		HSD used for transmitting GE/Burroughs data, raw radar data, and telemetry events to IMCC. Additional line used for real-time backup.
			2K bps		HSD used for transmitting IP data, raw radar data and telemetry events to IMCC. Additional line used for real-time backup.
			2K bps		HSD used for transmitting ephemeris data to GE/Burroughs. Additional line used for real-time backup.
			1K bps*		HSD used for transmitting command data from IMCC to CKEN. Additional line used for real-time backup.
			1K bps*		HSD used for transmitting commands from IMCC to BDA through CKEN. Additional circuits used for real-time backup.
WBD - Wide Band Data HSD - High Speed Data			TTY - Teletype FDT - Full Duplex Teletype		FD - Full Duplex * - Dibit Clock Rate

Table 4.4-1 Continued

SITE	VOICE	WBD	HSD	TTY	REMARKS
				100 wpm	Teletype used for transmitting orbital tracking data from CKEN to IMCC, and message traffic.
Canary Island	1 FD			2 FDT 60 wpm	Teletype used for message traffic, command acquisition, telemetry data, and tracking data.
Kano	1 FD			2 FDT 60 wpm	Teletype used for message traffic.
Zanzibar	1 FD			1 FDT 60 wpm	Teletype used for message traffic.
Carnarvon	1 FD			2 FDT 60 wpm	Teletype used for message traffic, command, acquisition, telemetry data, and tracking data.
Canton Island	1 FD			1 FDT 60 wpm	Teletype used for message traffic.
Hawaii	1 FD			2 FDT 100 wpm	Teletype used for message traffic, command, acquisition, and telemetry data.
Point Arguello	1 FD			1 FDT 100 wpm	Teletype used for message traffic, tracking, and acquisition data.
Guaymas	1 FD			1 FDT 60 wpm	Teletype used for message traffic, acquisition, telemetry data, and tracking data.

Table 4.4-1 Continued

SITE	VOICE	WBD	HSD	TTY	REMARKS
Bermuda	3 FD		4 Bermuda to IMCC 2K bps	2 FDT	HSD used for transmitting launch tracking data from Bermuda to IMCC. Additional line used for real-time backup.
			2K bps		HSD used for transmitting telemetry data from Bermuda to IMCC. Additional line used for real-time backup.
				100 wpm	Teletype used for transmitting orbital tracking data from Bermuda to IMCC, and for message traffic.
White Sands	1 FD			1 FDT 100 wpm	Teletype used for message traffic, tracking and acquisition data.
Corpus Christi	1 FD		2 IMCC/Texas	1 FDT 100 wpm	Teletype used for message traffic and for acquisition.
			2 TEX/IMCC 1K bps*		HSD used for telemetry data. Additional line required for real-time backup.
			1K bps*		HSD used for command traffic. Additional line required for real-time backup.
Eglin	1 FD			1 FDT 100 wpm	Teletype used for message traffic, tracking and acu
Rose Knot Victory	1 FD			1 FDT 60 wpm	Teletype used for message traffic, command, acquisition, and telemetry data.

Table 4.4-1 Continued

SITE	VOICE	WBD	HSD	TTY	REMARKS
Coastal Sentry Quebec	1 FD			1 FDT 60 wpm	Teletype used for message traffic, telemetry data, command data, acquisition, and tracking data.
Range Tracker	1 FD			1 FDT 60 wpm	Teletype used for message traffic, telemetry data, acquisition, and tracking data.
Recovery Control Center					No requirements defined at this time.
TLS				2 FDT 100 wpm	Teletype used for message traffic, telemetry data, acquisition, and tracking data.

4.5 TRAJECTORY DATA SUBSYSTEM

4.5.1 Sources of Information

The primary sources of information for the compilation of data given in this section are as follows:

a. "Communications Operations Procedure (COP-1)," X-531-62-5.

b. "Launch Trajectory Data System," System Engineering IBM/RTCC.

c. "Introduction to Project Mercury and Site Handbook," MG-101

d. "A Brief Survey of Tracking Networks and Systems," John Meson, NASA/MSC.

The geographic locations of GOSS tracking stations and the type of tracking equipment at each are shown in Figure 4.5-1. (Deep-space tracking is described in Section 3.5.)

4.5.2 Gemini Configuration

The location and types of equipment employed for Gemini are shown in Table 4.5-1. The Trajectory Data Subsystem will provide trajectory information to the CKEN/MCC or the IMCC from Lift-off to Re-entry for the Gemini vehicle, and as required for the Agena vehicle. The Launch and Orbital Phases of the Trajectory Data Subsystem are discussed below.

4.5.2.1 Launch Phase of the Trajectory Data Subsystem

The Gemini Trajectory and Guidance Data Subsystem (a part of the Gemini Launch Data System) performs the functions of acquisition of radar

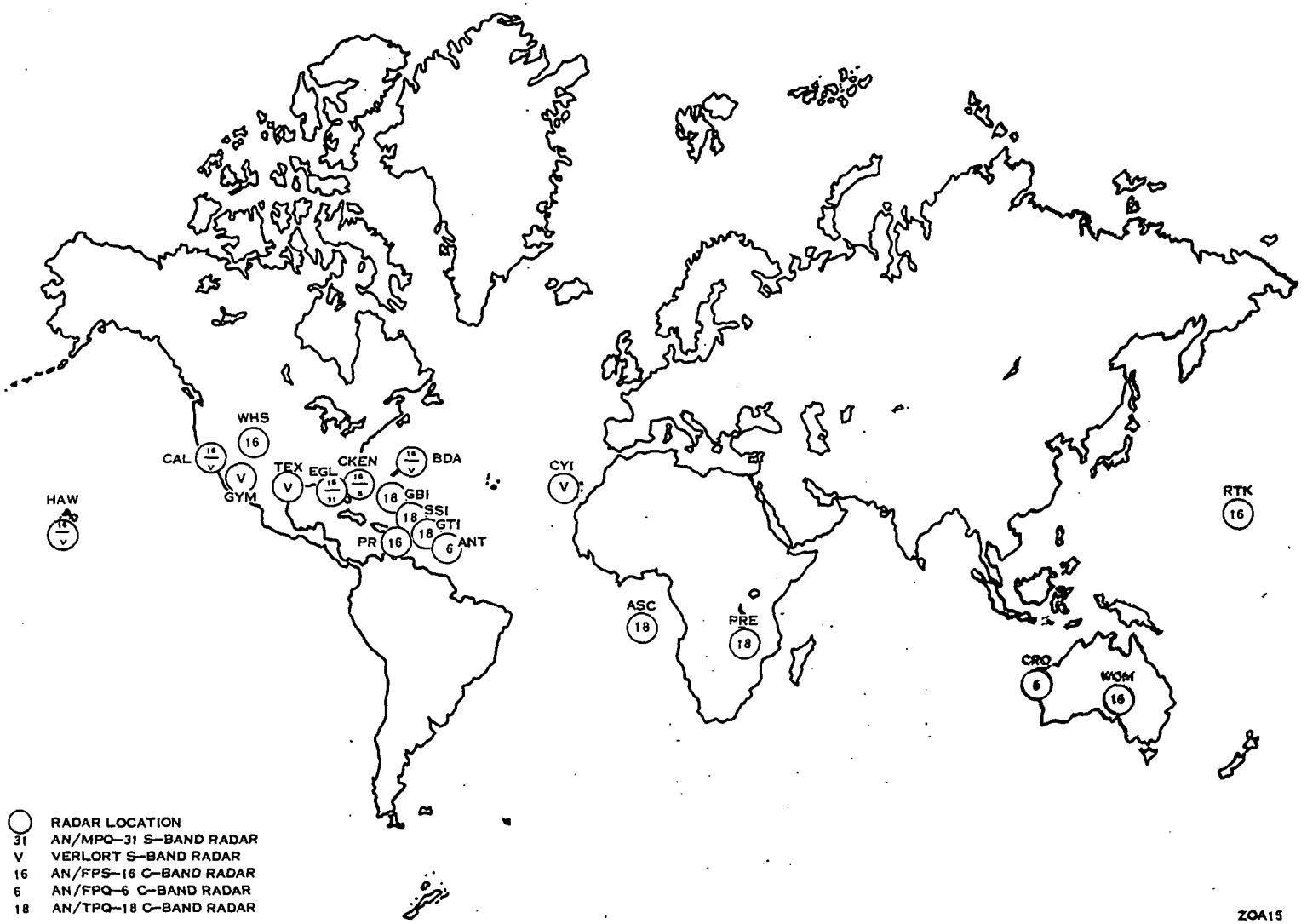


Figure 4.5-1 Tracking Stations and Equipment

Table 4.5-1 Radars at Near Space Instrumentation Facilities

Site	Code	Radars	
		C-Band	S-Band
Cape Kennedy	CKEN	AN/FPS-16	MOD. II
Bermuda	BDA	AN/FPS-16	Verlort
Grand Canary Island	CYI		Verlort
Carnarvon	CRO	AN/FPQ-6	
Woomera	WOM	FPS-16	
Hawaii	HAW	AN/FPS-16	Verlort
Point Arguello	CAL	AN/FPS-16	Verlort
Guaymas	GYM		Verlort
White Sands	WHS	AN/FPS-16	
Corpus Christi	TEX		Verlort
Eglin	EGL	AN/FPS-16	AN/MPQ-31
Range Tracker (PMR)	RTK	AN/FPS-16	

trajectory data from Atlantic Missile Range (AMR) and Bermuda Site (BDA) radars, the transmission of these trajectory data (together with selected telemetry events) to the Real-Time Computer Complex (RTCC) at the IMCC, and the transmission of necessary computed pre-launch data from the RTCC computers to Cape Kennedy. The subsystem is in an operational condition during the pre-launch and launch phases of both the Agena and Gemini vehicles, and remains operational until the Bermuda or Antigua sites lose track of the vehicles.

The TGD Subsystem contains three principle data links (Figure 4.5-2), as follows:

- Impact Predictor (IP) Data Link
- Guided Missile Control Facility (GMCF) No. 1 Data Link
- Bermuda (BDA) Data Link.

Data flow throughout the Trajectory Data Subsystem and the data transmission formats are shown in Figure 4.5-3. The major interfaces are as follows:

- CKEN and BDA data sources to Data Control Unit Transmitter (DCU(T))
- DCU(T) to Data Control Unit Receiver (DCU(R))

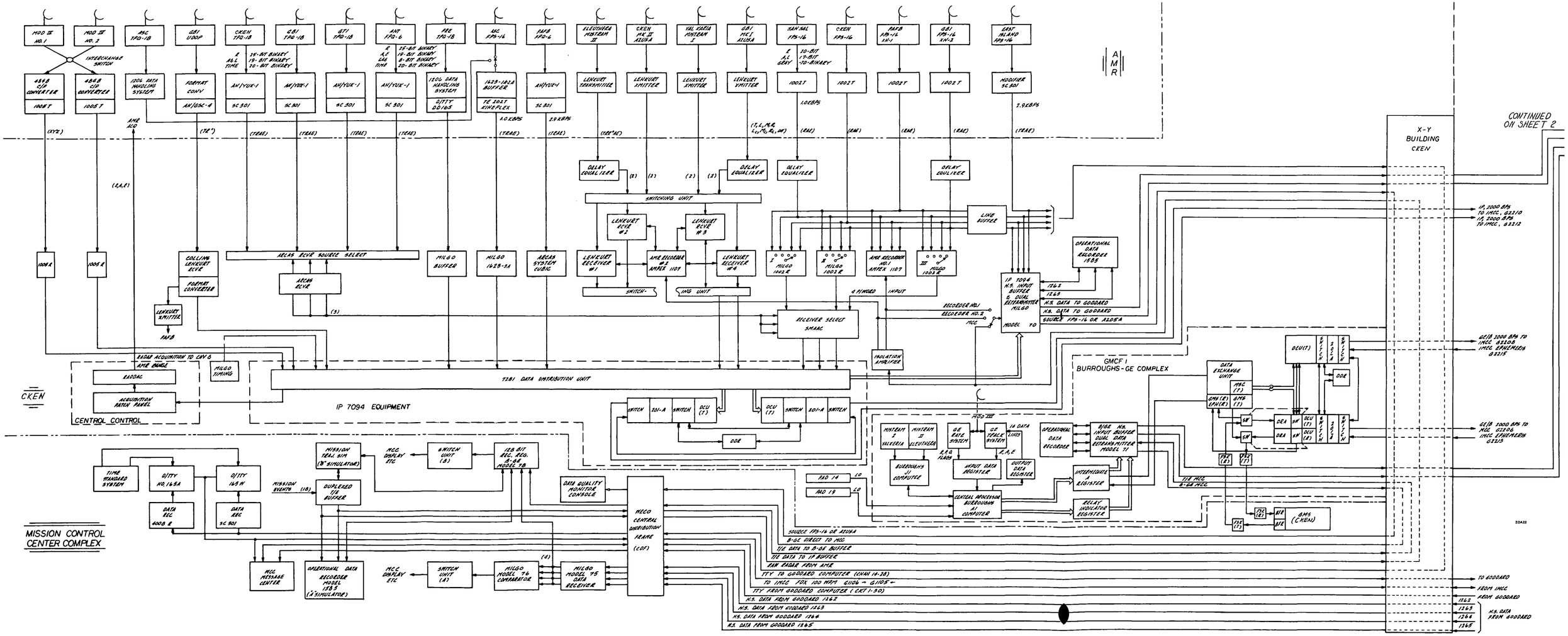


Figure 4.5-2 (1) Block Diagram of the Trajectory Guidance Data Subsystem Data Links

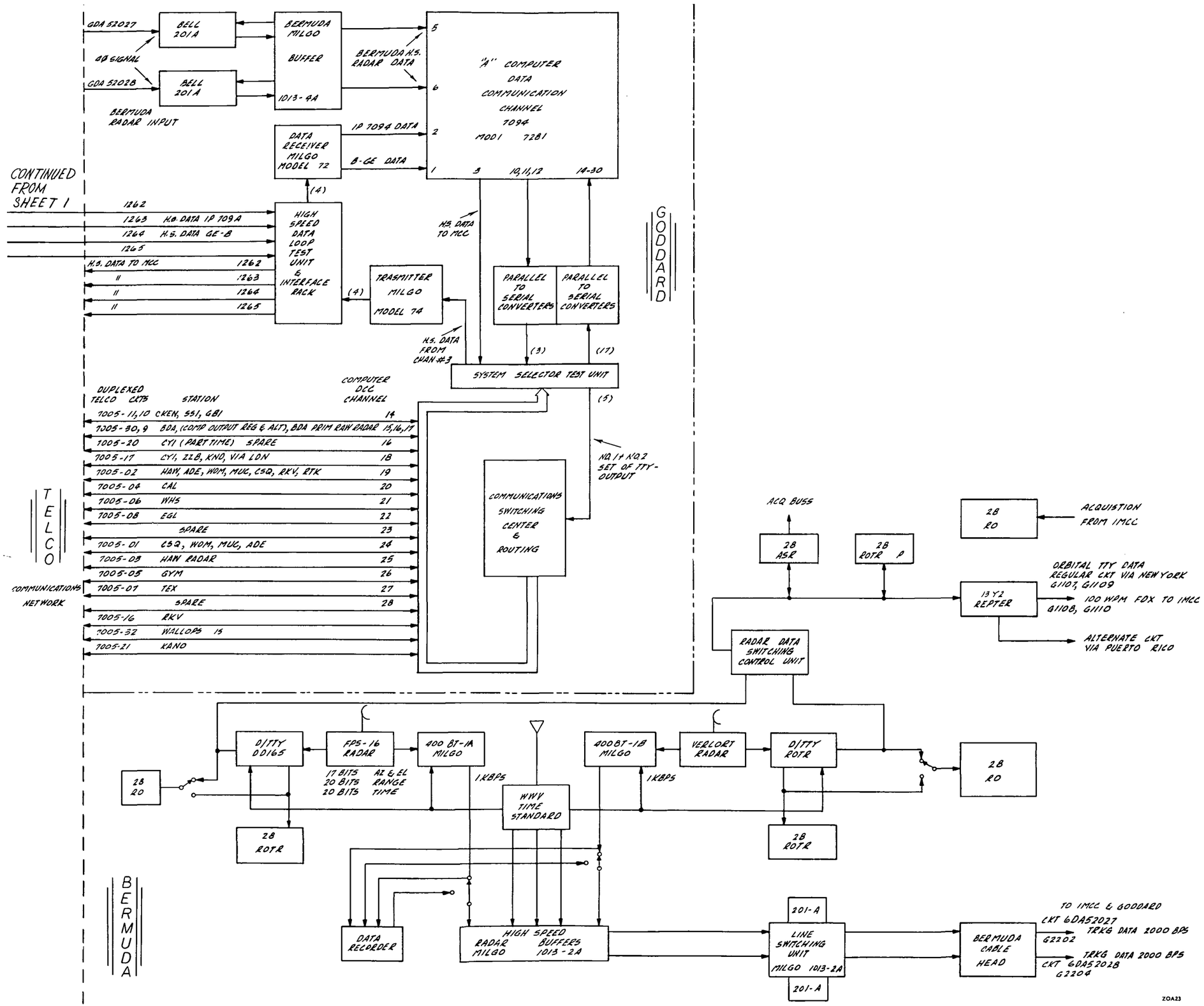


Figure 4.5-2 (2) Block Diagram of the Trajectory Guidance Data Subsystem Data Links

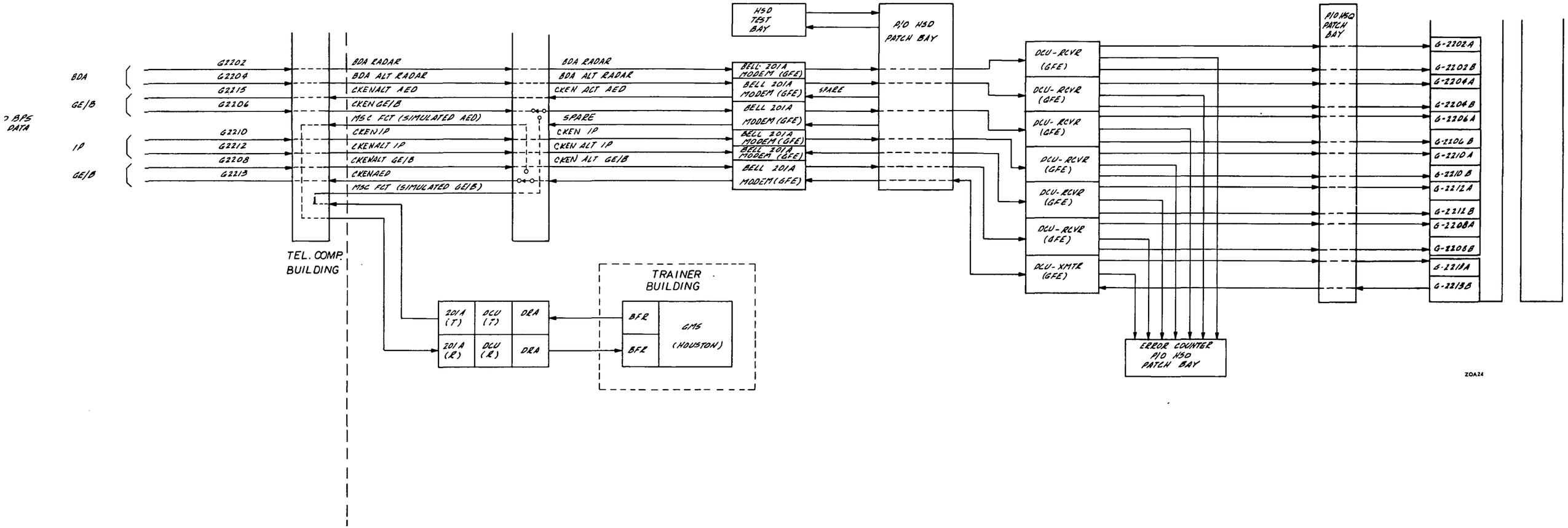
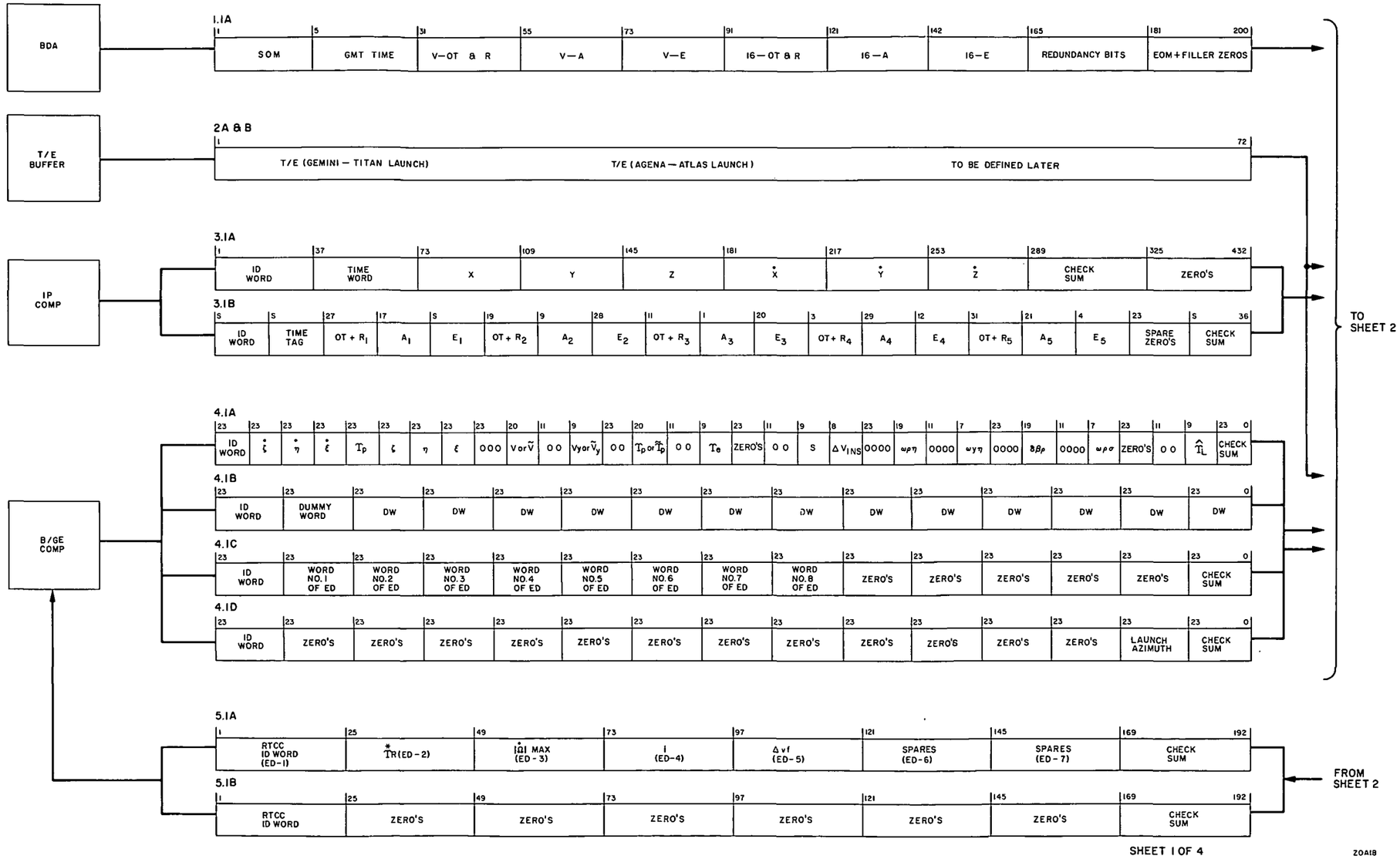


Figure 4.5-2 (3) Block Diagram of the Trajectory Guidance Data Subsystem Data Links



FORMAT

1.1A - 1.3A	FPS-16 AND VERLORT RADAR, BDA TO RTCC
2AB	TLM EVENTS CKEN T/E BUFFER TO CKEN/DCU'S
3.1A - 3.4A	IP FLIGHT DATA (SMOOTHED) IP COMPUTER TO RTCC
3.1B - 3.4B	IP FLIGHT DATA (RAW) IP COMPUTER TO RTCC
4.1A - 4.4A	GE/B COMPUTER FLIGHT DATA GE/B CKEN TO RTCC
4.1B - 4.4B	REQUEST FOR E/D FROM RTCC GE/B CKEN TO RTCC
4.1C - 4.4C	VALIDATION OF E/D GE/B CKEN TO RTCC
4.1D - 4.4D	LAUNCH AZIMUTH COMPUTATION DATA GE/B CKEN TO RTCC
5.1A - 5.4A	E/D FROM RTCC RTCC TO GE/B CKEN
5.1B - 5.4B	E/D VERIFICATION RTCC TO GE/B CKEN

SHEET 1 OF 4

Z0A18

Figure 4.5-3 (1) Trajectory and Guidance Data Subsystem Data Flow and Formats

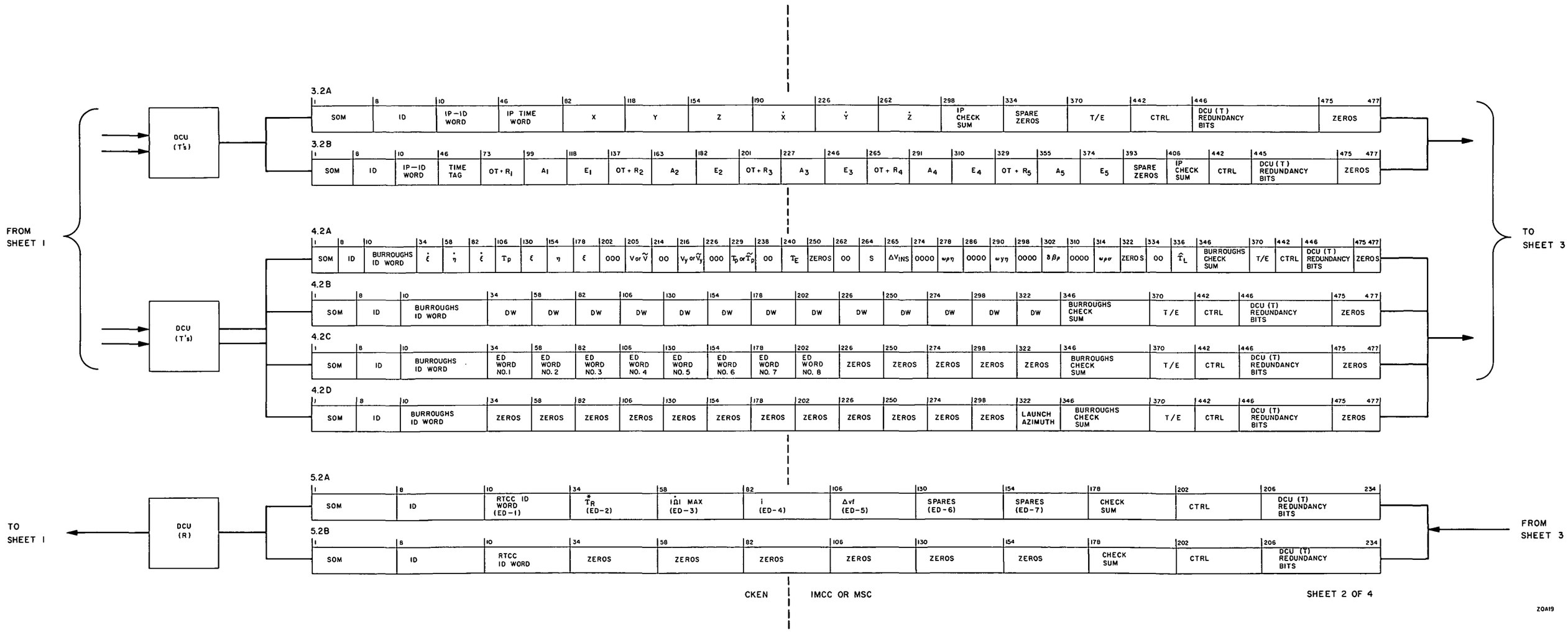


Figure 4.5-3 (2) Trajectory and Guidance Data Subsystem Data Flow and Formats

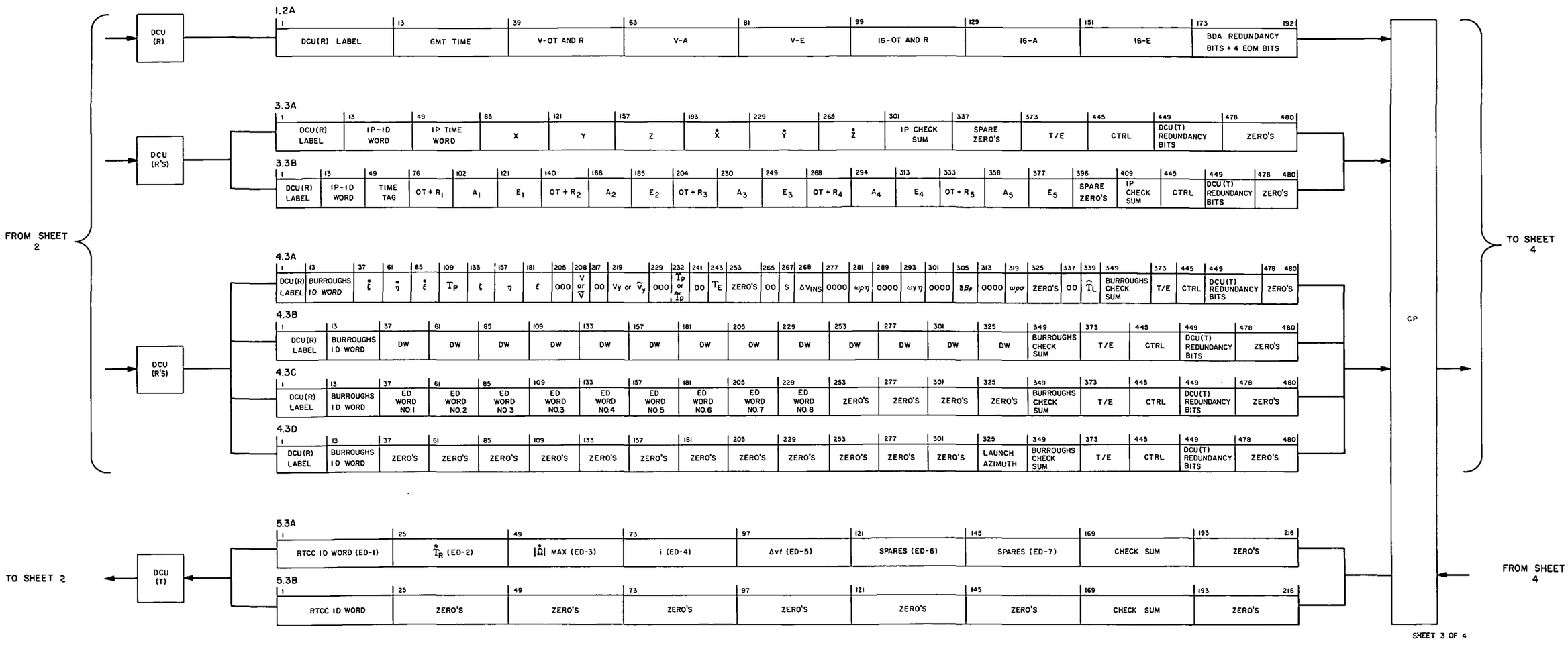


Figure 4.5-3 (3) Trajectory and Guidance Data Subsystem Data Flow and Formats

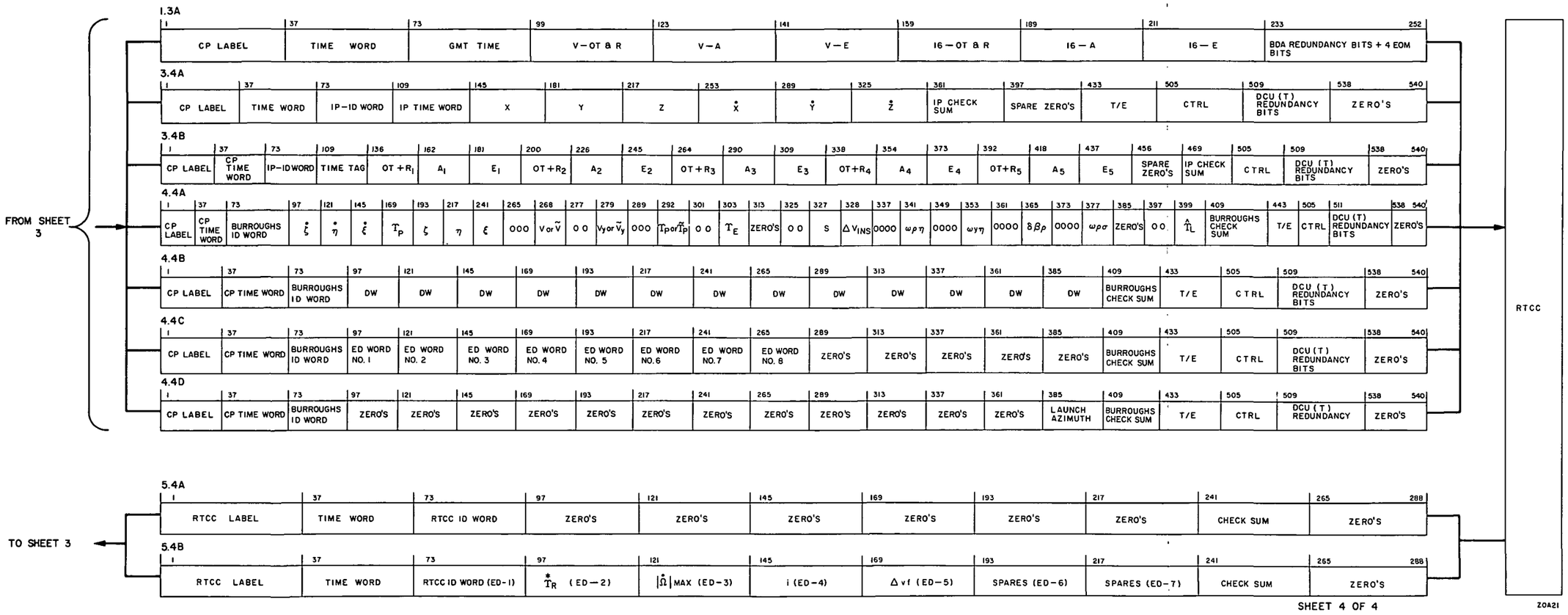


Figure 4.5-3 (4) Trajectory and Guidance Data Subsystem Data Flow and Formats

- DCU(R) to Comm Processor
- Comm Processor to RTCC.

The format quantities are given in Table 4.5-2.

a. Impact Predictor Data Link. Tracking data acquired by the AMR radars are transmitted to the Impact Predictor (IP) Complex via normal CKEN transmission facilities. This complex, which presently consists of an IBM 7094 Computer, will be modified to include two CDC 3600 Computers in an operational/standby mode by late 1964. The IP Complex processes the received data, and forwards them in two forms to two DCU(T) units for retransmission. One form of data contains Time-Range-Velocity (TRV) vectors, and the other form contains unprocessed Time-Range-Azimuth-Elevation (TRAE) vectors. Each form is available in alternating sequence every 0.5 second to the DCU(T)'s. Effective message rate from the IP Complex is therefore one message each 0.25 second.

The DCU(T)'s also receive Telemetry Events (T/E) information from the Mission Control Center at Cape Kennedy. These data contain selected events from the operational Telemetry System, from the Launch Blockhouse, and from internal sources. The T/E message rate is one message per 74 ms.

Each DCU(T) merges received trajectory and T/E data, adds necessary control information and redundancy bits, and transmits the resultant block

Table 4.5-2 Glossary of Format Quantities

Symbol	Parameter
	A. IP COMPUTER
X, Y, Z	POSITION
$\dot{X}$, $\dot{Y}$, $\dot{Z}$	Velocity Component
IP Time Word	Time tag in GMT
	B. GE/BURROUGHS COMPUTER
$\zeta, \eta, \xi,$	POSITION
$\dot{\zeta}, \dot{\eta}, \dot{\xi}$	Velocity Component
T	Message Time in GMT
$\omega_{\rho\eta}$	Pitch Rate Command Output (limited)
$\omega_{y\eta}$	Yaw Rate Command Output (limited)
$\delta\beta\rho$	Pitch Attitude Error
$\omega_{\rho\sigma}$	Component of ω_ρ to satisfy insertion altitude requirement
V_y	Intertial Velocity normal to target plane
$\tilde{V}_y$	Intertial Velocity normal to launch plane minus initial (lifeoff) velocity component in that plane
T_E	Effective time to go to SECO
$\hat{T}_L$	Elapsed time since liftoff
	C. EPHEMERIS DATA
T_R	Time (GMT) that latitude-longitude 0, 0 passes through the Agena instantaneous orbit plane (seconds)
$\lvert\dot{\Omega}\rvert$Max	Last maximum magnitude of the Agena orbit plane precession rate (rad/sec)
	Last orbit average inclination angle of the Agena orbit plane (radians)

of data via Bell System 201-A Data Modems and TELPAC lines to the DCU(R)'s in the IMCC at Houston. The data transmission rate is 2K bps. Each message block consists of 474 bits transmitted at a clock rate of four messages per second. Filler blocks containing logical ZERO's are transmitted between message blocks to permit a continuous transmission mode of operation. Alternate message blocks contain smoothed trajectory data and T/E data, and intermediate message blocks contain only raw radar data.

Each DCU(R) in the IMCC at Houston identifies valid message blocks containing no transmission errors, removes transmission control bits, adds an identification label, and transmits the resultant data train to the Communications Line Terminal (CLT) which is the input device to the Communications Processor. Valid message blocks which contain transmission errors are transmitted to the Communications Processor in the same manner but are identified as containing erroneous data. Filler blocks are not retransmitted by the DCU(R)'s.

The Communications Processor provides a store-and-forward function for the messages from the DCU(R)'s. Additional identification data are added to the received messages, and the resultant data again are retransmitted to the RTCC at a nominal rate of 40.8K bps.

Data transmission is made over two transmission paths from Cape Kennedy to the RTCC to assure operational reliability of the data link. One path is designated as the primary link, and the other path is

designated as the secondary link. The RTCC first examines data from the primary link. These data are utilized in computation routines if they do not contain transmission errors which are shown by transmission validity flags from the DCU(R)'s, and if the trajectory check sum and T/E parity-bit within each message block are correct. Otherwise, data from the secondary link are used for computation, providing that the same check conditions prove valid. If data from neither link are free of transmission errors, the RTCC recovers data within each message, based only upon trajectory check sums and T/E parities as possible from each link. If useful data can not be recovered under any conditions, the RTCC discards the invalid messages and awaits new data for updating computations.

b. Guided Missile Control Facility No. 1 Data Link. Tracking data from either the GE MOD III Radar, or from MISTRAM sources, are received by the GE/Burroughs A-1 Computer within the GMCF No. 1 Complex. These data are processed by the computer to form TRV vectors, and, together with certain events information, are forwarded to the DCU(T)'s for retransmission. Message rate from the computer is one message each 0.5 second.

The DCU(T)'s also receive T/E information from the Mission Control Center, as in the case of the IP Data Link. Each unit merges trajectory and T/E data, adds necessary control information and redundancy bits, and transmits the resultant block of data via Bell System 201-A Data Modems and TELPAC lines to the DCU(R)'s in the IMCC at Houston. The data transmission rate is 2K bps. Each message block consists of 474 bits transmitted at a

rate of two blocks per second. Filler blocks containing logical ZERO's are transmitted between message blocks to permit a continuous transmission mode of operation.

The data train received at the IMCC is processed in the same manner by the DCU(R)'s as for the IP Data link, and is retransmitted to the Communications Processor in the same manner. The Communications Processor performs the same store-and-forward function for processing the message block to the RTCC. Use of the data within the RTCC is similar to the use of the IP data previously described.

The return path of the primary link between the GMCF No. 1 Complex and the RTCC is utilized for transmission of prelaunch data to the GE/Burroughs Computer at Cape Kennedy. Ephemeris data for the first launch vehicle are transmitted by the RTCC approximately fifteen minutes before launch of the second vehicle. Transmission of these data is continued until the GE/Burroughs Computer acknowledges receipt of a correct data block, and this acknowledgement is verified by an RTCC computer. Normally, only one ephemeris message transmission will be required in the absence of transmission errors.

The ephemeris message is generated by the RTCC and forwarded via the Communications Processor to the DCU(T). The DCU(T) adds control information and redundancy bits, and transmits the resultant message block via the 201-A Data Modems and TELPAC lines to the DCU(R)'s at the GMCF No. 1

Complex. The data transmission rate is 2K bps. A message block consists of 234 bits transmitted at a rate of two blocks per second. Filler blocks are transmitted between message blocks.

The DCU(R) processes the ephemeris data in the same manner as the receivers at the IMCC handle the trajectory data. The resultant data train is transmitted directly to the GE/Burroughs Computer at Cape Kennedy whenever a valid message block is detected by the DCU(R).

At T-3 minutes in the countdown of the second vehicle, the GE/Burroughs Computer at Cape Kennedy sends computed second vehicle launch azimuth data for a period of 20 seconds (about 40 messages) to the RTCC via the two operational GE/Burroughs Computer data links.

c. Bermuda Data Link. Verlort and AN/FPS-16 radar tracking data are received directly from the radars by the Radar Data Buffers (RDB's) at the Bermuda Site, together with GMT time data from the local Time Standard Unit. Each RDB merges the received data into the proper format, adds necessary control information and redundancy bits, and transmits the resultant block of data via 201-A Data Modems and TELPAC lines to the DCU(R)'s in the IMCC at Houston. The data transmission rate is 2K bps. Each message block consists of 184 bits transmitted at a rate of ten blocks per second. Filler blocks consisting of logical ONE's and ZERO's are transmitted between message blocks to permit a continuous transmission mode of operation. It should be noted that data transmission and data formats are the same as for Project

Mercury, and that the data link is the same until the transmission arrives within the United States. Mercury and Gemini data links then differ to permit the data to reach the Goddard Space Flight Center and the IMCC at Houston, as appropriate.

The data train received at the IMCC in Houston is processed in the same manner by the DCU(R)'s as for the IP Data Link, and is retransmitted to the Communications Processor in the same manner. The Communications Processor performs the same store-and-forward function to process the data to the RTCC.

4.5.2.2 Orbital Phase of the Trajectory Data Subsystem

The Orbital Phase of the Trajectory Data Subsystem has the capability of providing radar trajectory data from the Near Space Instrumentation Facilities (NSIF) and of transmitting selected data events to the IMCC via teletype. The subsystem is in the operational mode from the time of Orbital Insertion of the Gemini or Agena vehicle and remains operational until Re-entry. NSIF sites, through the use of both S-Band and C-Band tracking radars, have the capability of simultaneously tracking the Agena and Gemini vehicles.

Vehicle position information is provided by S-Band and C-Band tracking radars (Table 4.5-1). Data outputs from the tracking radar digital shaft encoders are 20-bit range words and 17-bit angle words from the C-Band trackers, and 16-bit angle words from the S-Band trackers. The digital

Table 4.5-3 Sites and Acquisition Aid Equipment for Gemini

Site	Code	Equipment & Systems	Manufacturer
Cape Kennedy	CKEN	TLM-18	Radiation
		Mod. II Radar	GE
		Teltrac Receiver System	Canoga
		Telar Antenna	Canoga
Atlantic Missile Range	AMR*		
Bermuda	BDA	Teltrac Receiver System	Canoga
		Agave Model Antenna	Cubic
Canary Island	CYI	Teltrac Receiver System	Canoga
		Telar Antenna	Canoga
		Agave Model Antenna	Cubic
Kano	KNO	Simplified Agave System	Cubic
		Acquisition Data Console	Bendix
Zanzibar	ZZB	Simplified Agave System	Cubic
		Acquisition Data Console	Bendix
Carnarvon	CRO	Teltrac Receiver System	Canoga
		Telar Antenna	Canoga
Woomera	WOM	Agave System	Cubic
Canton Island	CTN	Simplified Agave System	Cubic
		Acquisition Data Console	Bendix
Hawaii	HAW	Agave Model Antenna	Cubic
		Telar Antenna	Canoga
		Teltrac Receiver System	Canoga
Point Arguello	CAL	Agave System	Cubic
Guaymas	GYM	Agave System	Cubic
		Telar Antenna	Canoga
		Teltrac Receiver System	Canoga
White Sands	WHS	Agave without HF Antenna System	Cubic

*Acquisition information at time of launch is selected from Mod II Radar, Telemetry Antennas, and/or Opties.

Table 4.5-3 Continued

Site	Code	Equipment & Systems	Manufacturer
Corpus Christi	TEX	Agave Model Antenna	Cubic
		Telar Antenna	Canoga
		Teltrac Receiver System	Canoga
Eglin	EGL	Agave without HF Antenna System	Cubic
Rose Knot Victory	RKV	Agave Antenna	Cubic
		Teltrac Receiver System	Canoga
Coastal Sentry Quebec	CSQ	Agave Antenna	Cubic
		Teltrac Receiver System	Canoga
Range Tracker	RTK	Teltrac Receiver System	Canoga
		Telar Antenna	Canoga
Terminal Landing System	TLS	UHF/RDF	

outputs are converted to teletype format by Digital-to-Teletype Converters. Major interfaces are: Tracking radar to Digital-to-Teletype Converters, Digital-to-Teletype Converters to communication links, and communication links to the Communications Processor. Trajectory Data Communication Links are shown in Figure 4.5-4. Simplified block diagrams of the S-Band and C-Band trajectory measurement devices are shown in Figure 4.5-5.

a. Digital-to-Teletype Converter. The Milgo Model 165 Digital-to-Teletype Converter receives digital information (representing azimuth angle, elevation angle, and slant range) from either a Verlort radar or an FPS-16 radar or a Milgo Model 4008 Data Receiver. It converts this information in Gray Code to straight binary code when necessary, and arranges it in the format needed for transmission over commercial teletype lines. It also accepts parallel data, representing time of day, from the Binary Code Translator in a BCD format, and incorporates this information into the total data word. A modified Digital-to-Teletype Converter (Model 165W) is utilized with the AN/FRQ-6 at CRO. The sampling rate of the converter is one per six seconds.

The Digital-to-Teletype Converter generates a heading, and gives station number, radar type and data validity. On command, it produces and transmits a Start-of-Message group of teletype characters. It also generates, on command, an End-of-Message group of characters, which is sent immediately after the last data word.

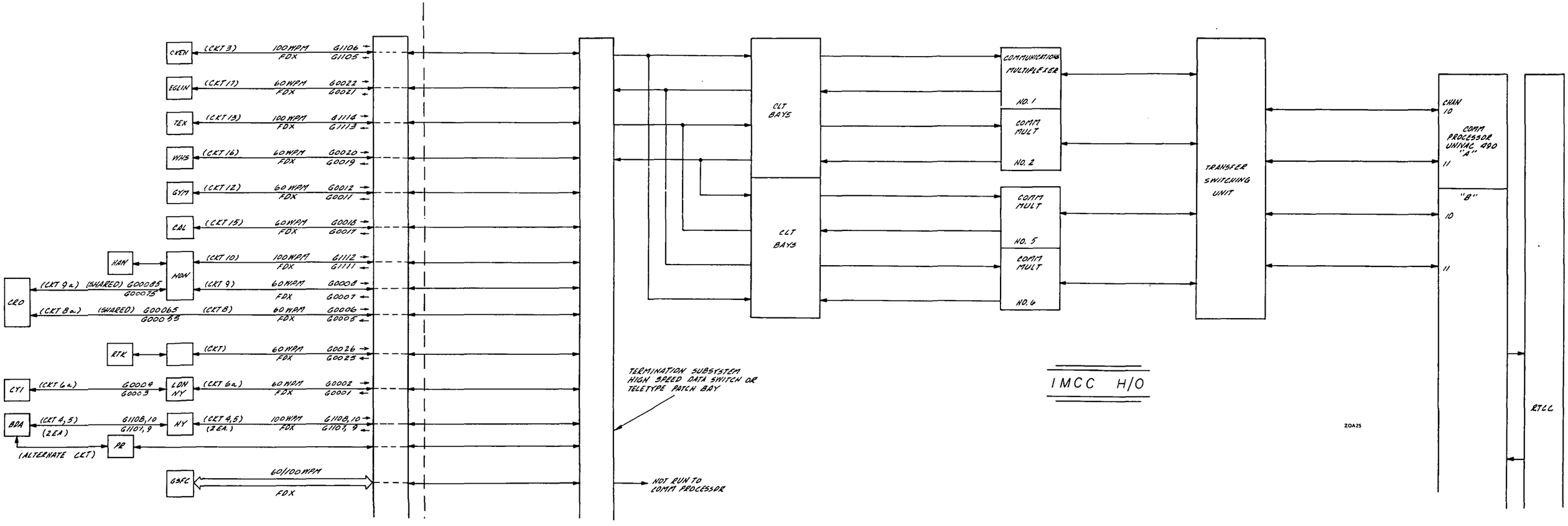


Figure 4.5-4 Trajectory Data Communications Links

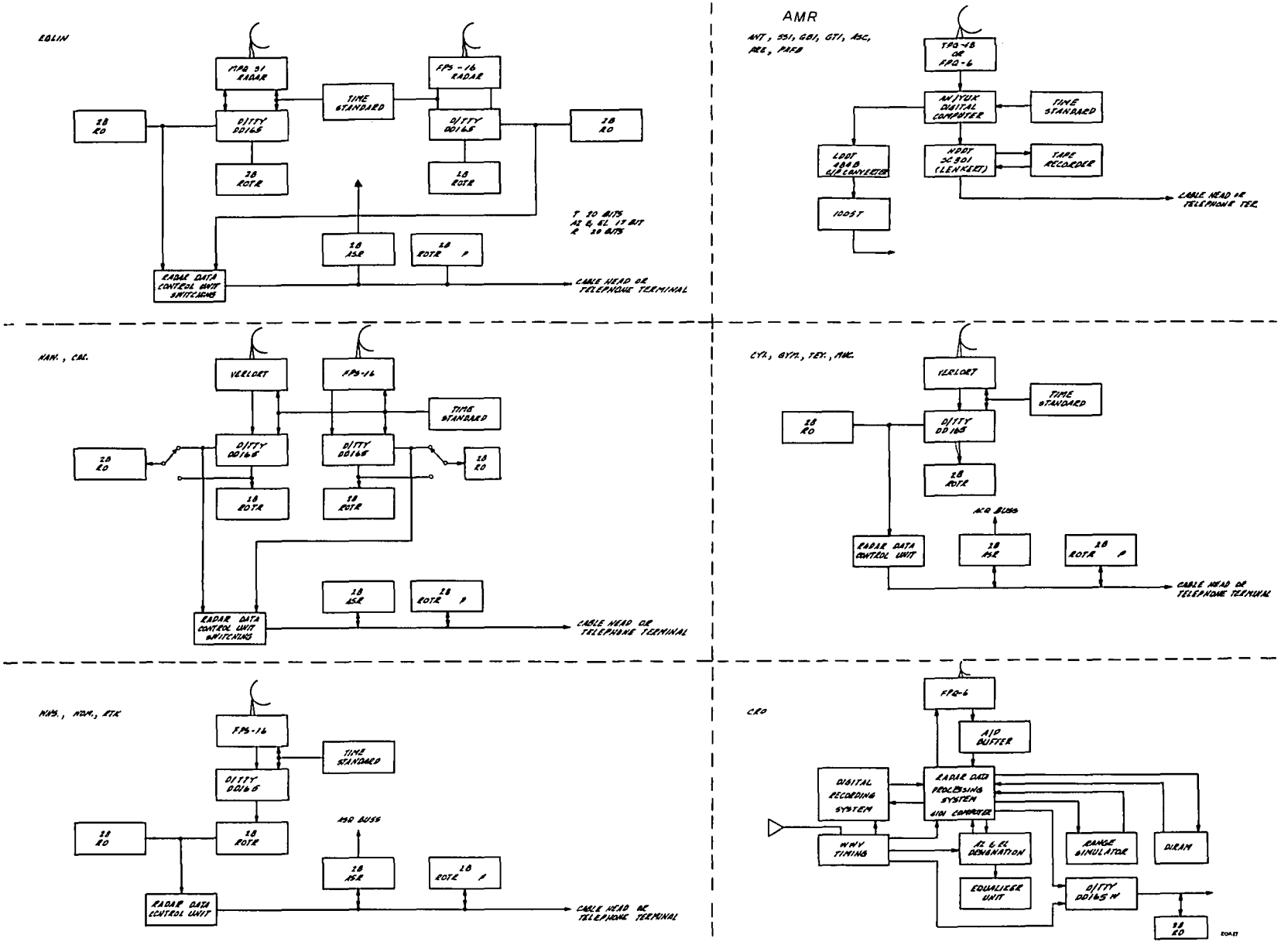


Figure 4.5-5 Simplified Block Diagram of the S-Band and C-Band Radars

The Bermuda Verlort and AN/FPS-16 radar data are also merged with independent time data, properly formatted, combined with the control and error code data, and are sent by the radar buffer to the 201-A Data Modems for encoding and transmission over land line circuits and submarine cable to the Communications Processor. Two independent data channels are provided in the radar buffers, each transferring, to its own 201-A Data Modem and land line, identical data as processed by each buffer channel.

The operational data recorder records the input signal to the two data buffers. This unit has switch controls which allow the recorded information to be played back to the radar buffer, data transmitters and data receivers.

b. Teletype Message Format. Teletype messages are sent out serially over the communication lines at the rate of either 60 or 100 wpm, depending upon the terminal equipment. Each character contains its own START pulse, as well as a STOP pulse, so that transmission may be carried through in an asynchronous mode.

The Communications Processor receives and sends teletype information by means of a communications subsystem consisting of a Communications Line Terminal (CLT) and Communications Multiplexer. The CLT's used for teletype are the 8IL for input and the 80L for output. The multiplexer enables a number of lines to be terminated in a single computer input/output channel.

c. Teletype Radar Data Message Format. Each radar teletype message (Figure 4.5-6) consists of a Start-of-Message, a variable number of fixed frames and an End-of-Message. The message frame format is described below.

(1) Start of Message. Each message starts with a fixed sequence of characters: two J's, one LTR, one CR, one LF, and one LTR.

(2) Frame Header. Start of frame consists of one LF and two FIG's.

(3) Frame Description. Fixed format that contains:

- One character denoting "kind of data"
- Two characters denoting "station identity"
- One character denoting "type of radar"
- One character denoting "data validity".

(4) Frame Body. Fixed format that contains:

- Time, six characters
- Azimuth, six characters
- Elevation, six characters
- Range, seven characters.

(5) End of Frame. End of frame consists of one CR.

(6) End of Message. End of Message consists of a fixed format containing one blank SPACE followed by one FIG, one symbol (#), and one LTR.

4.5.2.3 Acquisition System

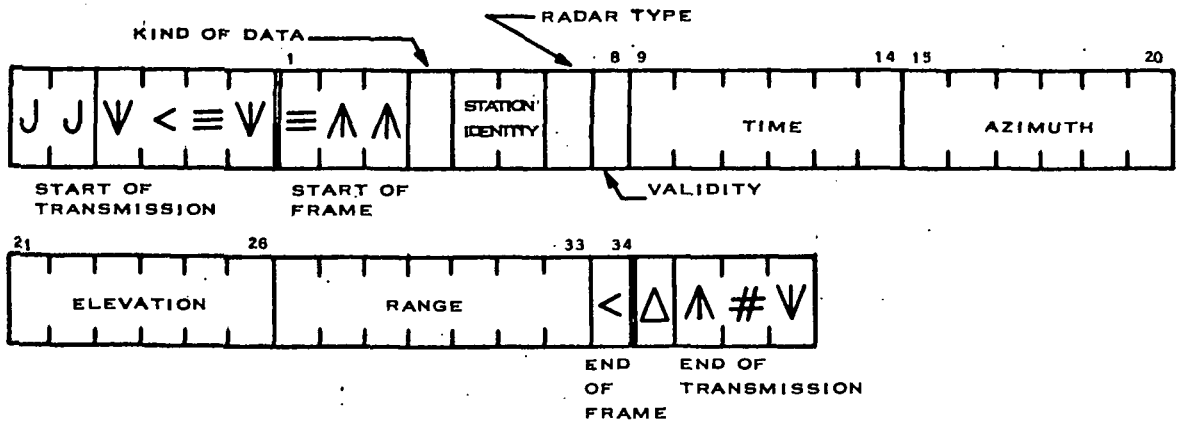
The function of the Acquisition System is to supply the best available data on the azimuth and elevation of the spacecraft to the steerable antennas on the site.

The Acquisition System is a tracking system which provides a relatively large antenna beamwidth that insures acquisition of a spacecraft in

Table 4.5-3 Sites and Acquisition Aid Equipment for Gemini

Site	Code	Equipment & Systems	Manufacturer
Cape Kennedy	CKEN	TLM-18	Radiation
		Mod. II Radar	GE
		Teltrac Receiver System	Canoga
		Telar Antenna	Canoga
Atlantic Missile Range	AMR*		
Bermuda	BDA	Teltrac Receiver System	Canoga
		Agave Model Antenna	Cubic
Canary Island	CYI	Teltrac Receiver System	Canoga
		Telar Antenna	Canoga
		Agave Model Antenna	Cubic
Kano	KNO	Simplified Agave System	Cubic
		Acquisition Data Console	Bendix
Zanzibar	ZZB	Simplified Agave System	Cubic
		Acquisition Data Console	Bendix
Carnarvon	CRO	Teltrac Receiver System	Canoga
		Telar Antenna	Canoga
Woomera	WOM	Agave System	Cubic
Canton Island	CTN	Simplified Agave System	Cubic
		Acquisition Data Console	Bendix
Hawaii	HAW	Agave Model Antenna	Cubic
		Telar Antenna	Canoga
		Teltrac Receiver System	Canoga
Point Arguello	CAL	Agave System	Cubic
Guaymas	GYM	Agave System	Cubic
		Telar Antenna	Canoga
		Teltrac Receiver System	Canoga
White Sands	WHS	Agave without HF Antenna System	Cubic

*Acquisition information at time of launch is selected from Mod II Radar, Telemetry Antennas, and/or Optics.



FIGURES ⋀

LETTERS ⋁

SPACE Δ

CARRIAGE RETURN <

LINE FEED ≡

ZOA14

Figure 4.5-6 Trajectory Data Teletype Format

a large solid angle. It consists of two major subsystems: Antenna Positioning Subsystem and Receiving Subsystem. The combinations of antenna positioning equipment and receivers for the Remote Sites are listed in Table 4.5-3.

The antenna is positioned prior to a spacecraft pass by manually entering predicted azimuth and elevation data. These spacecraft position data are generated by the computers at the Goddard Space Flight Center or at the IMCC, and are sent via teletype to the site. After one of the active acquisition aids has acquired and starts tracking the spacecraft, continuous azimuth and elevation data are inputted to the Acquisition Buss for use by all the other steerable slaved antennas on site. The output information is in the form of synchro data.

a. Gemini Acquisition Buss. A new Gemini Acquisition Buss that will allow ground tracking stations to simultaneously acquire two space vehicles is now in production.

The Gemini Acquisition Buss (Figure 4.5-7) will provide the operator of each tracking radar with the capability of slaving the tracker in azimuth and elevation to data from an acquisition aid, radar, and/or computer. (Provisions for a spare position have been included in the design for future expansion.) A network of synchro data transmission busses interconnecting all the steerable antennas at a site provide this capability. Each subsystem will provide all other subsystems position information as to which

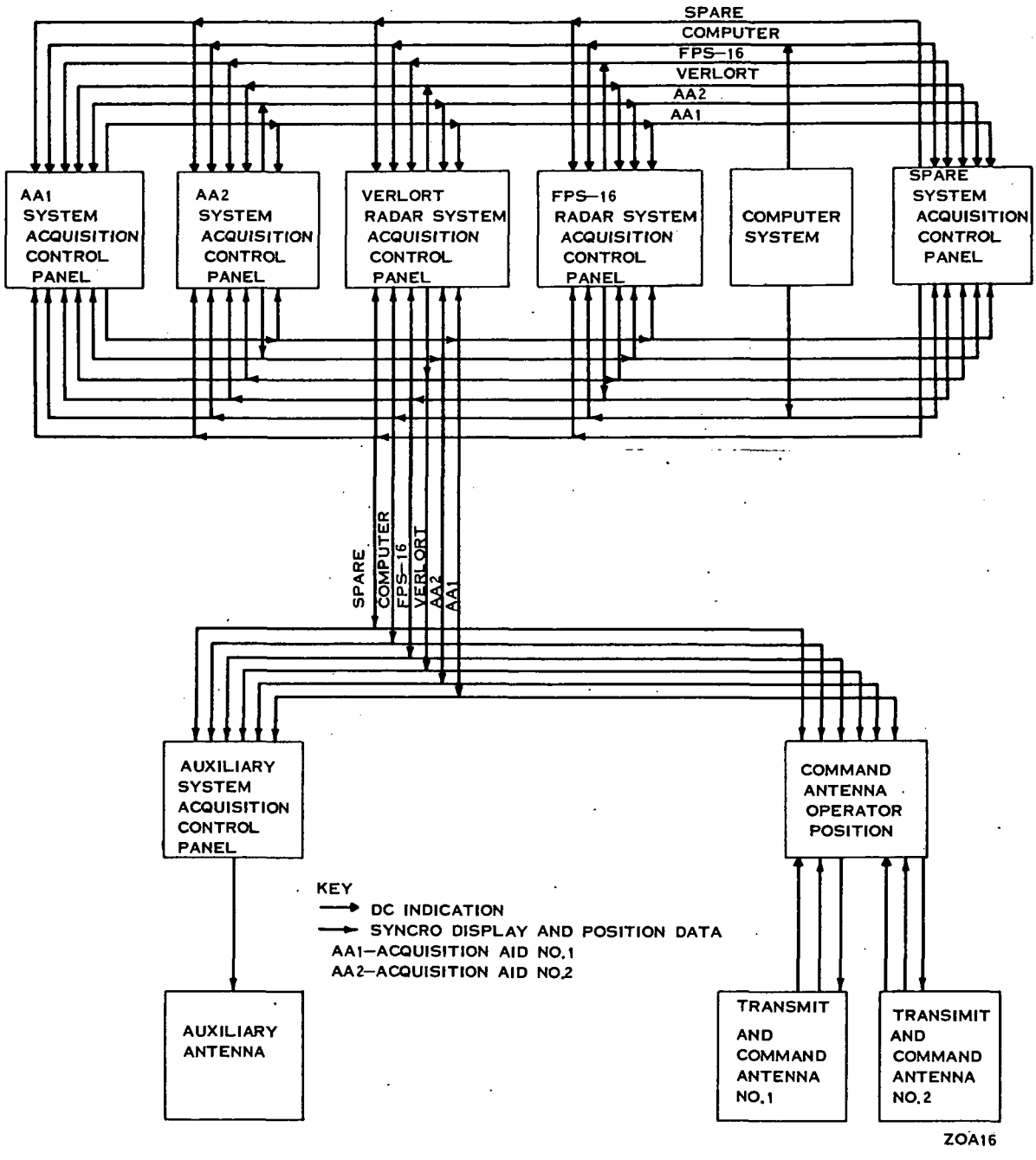


Figure 4.5-7 Block Diagram of the Gemini Acquisition Buss System

spacecraft is being tracked, the validity of the data, and the cable wrap indications where applicable. Remote control of the command antennas has been incorporated.

b. Acquisition Message Format. The acquisition message is transmitted in plain text from an IMCC or GSFC computer to each station a few minutes before the capsule rises above the local horizon.

The message describes four points on the expected path of the capsule over the station: Predicted time (hours, minutes, and seconds, in GMT), range (thousands of yards), azimuth (tenths of degrees), and elevation (tenths of degrees). The first point is 1 degree above the horizon, the second is the position of the capsule after it has moved through 10 degrees of radar arc, the third is the position of the capsule after moving through 30 degrees of radar arc, and the fourth is a set of values that predicts the position of the capsule 10 seconds (time) after the capsule has made its closest approach to the station.

Since this message is generated by the computer, it will not specify the originating station in the address portion of the message. Thus, the position normally reserved for the designation of the originating station is omitted in this format.

Since this message is generated by a computer at the IMCC or the GSFC, and is automatically transmitted, it is not given a precedence status.

The acquisition message text from the IMCC has yet to be determined.

A sample of the acquisition message text from the GSFC computer is as follows:

GMT	Range	Azimuth	Elevation
142710	1563	247.0	001.0
142834	0913	248.1	009.7
142928	0508	251.7	022.8
143134	0234	050.2	074.6

SECTION 5

SUPPORT SUBSYSTEMS

5.1 GENERAL

(To be provided later.)

5.2 SIMULATION, CONTROL AND TRAINING SYSTEM

(To be provided later.)

5.3 GOSS CHECKOUT AND DATA FLOW TESTS

(To be provided later.)

5.4 POST-MISSION DATA ANALYSES

(To be provided later.)

SECTION 6

GROUND EQUIPMENT PERFORMANCE SPECIFICATIONS

6.1 GENERAL

Table 6.1-1 is a key to the tables giving the Ground Equipment Performance Specifications, with cross references to the equipment lists given in Section 3.

Table 6.1-1 Master Table of Performance Specifications

(To be supplied later)

Table 6.2-1 Performance Specifications on the Canoga Model Teltrac Active Acquisition Aid

Parameter	Specification
Frequency range	Tracking, 216 to 260 mc Voice, 265 to 300 mc
Polarization	Right- or left-hand circular, and linear vertical or horizontal
Sum channel antenna gain	18 db (min) at 216 mc
Antenna system outputs	Sum and difference (based upon a phase-sensitive monopulse technique) for azimuth and elevation errors
Beamwidth at 3 db down	About 15 degrees
Side-lobes	-18 db (min) with respect to main lobe in all planes, and -26 db in principal planes
Receiver noise figure	4.5 db (max)
Acquisition noise bandwidth Cross-correlation Phase lock loop	 Plug-in 10, 30, 50, 100, 300, 500 750 cps, 300 cps and 1000 cps
Fine tuning range	80 kc (min)
Typical acquisition signal-to-noise ratio	3 to 6 db
Angular accuracy	0.5 degree RMS in azimuth and elevation between elevation angles of 15 degrees and 75 degrees (when the target is not obstructed by structures or obstacles and when secant correction is employed)
Angular acceleration	5 degrees/sec/sec
Angular travel	700 degrees in azimuth, -10 to +190 degrees in elevation
Angular rate	20 degrees/sec (track) 30 degrees/sec (slew)

Table 6.2-2 Performance Specifications on the Cubic Model Agave Active Acquisition Aid

Parameter	Specification
Frequency	Capable of tracking either of two telemetry frequencies in the 225-to 260-mc band when the modulation index is greater than one
Frequency Switching	Instantaneous switching between telemetry frequencies. Boresight transmitter is automatically switched to selected telemetry frequency.
Tracking Error	The maximum tracking error in automatic or manual modes is 0.5 degrees in azimuth, and 0.5 degrees in elevation when the elevation angle is greater than 15 degrees. For elevation angles between 10 and 15 degrees, the tracking error will not exceed 1.0 degrees. Tracking accuracy below elevation angles of 10 degrees will depend on multipath conditions.
Receiver	
Sensitivity	Greater than -150 dbw
Spurious Response	Greater than 125 db rejection
UHF Voice Comm	Approximately 18 db gain from UHF voice output at Triplexer
Telemetry Outputs	Approximately 28 db gain on telemetry outputs at RF housing
HF Voice Comm	Approximately 5 db gain from dipole array. Output is available at antenna pedestal.
RF Amplifier	
Frequency Range	225 to 260 mc
Gain	Approximately 24 db
Noise Figure	Less than 4 db
Bandwidth	35 mc between 3 db down
IF Stage	
Gain	60 db at threshold
Dynamic Range	Output constant to 2 db over input range of 70 db
Frequencies	35 mc, 2.2 mc and 10 kc
Crystal Filter	
Center Frequency	2.2 mc
Bandwidth	2 kc between 3 db down
Q of Filter	Approximately 1,100

Table 6.2-2 Continued

Parameter	Specification
Correlation Detector	
Frequency	2.2 mc
Bandwidth	30 kc
Voltage Controlled Oscillator	
Output Frequency	32.8 mc ± 40 kc
Modulation Frequency Response	0 to 5 kc
Phase Lock	Will lock on a signal with modulation index of 1 in less than 1 second
Phase Detector	
Input Frequency	10 kc
Output	Direct Current
Sensitivity	Approximately 0.1 volt per bore-sight-angle degree
Hybrid Ring	
Insertion Loss	Less than 0.24 db
VSWR	1.2:1 between 225 and 260 mc 1.33:1 between 260 and 300 mc

Table 6.3-1 Performance Specifications on the Verlort Tracking Radar

Parameter	Specification
Transmitting Section	
Frequency	2700 to 2900 mc
Magetron	Type 5586
Peak Power Output	150 kw minimum
Pulse Repitition Rate	410, 512, or 584 pps
Pulse Width	0.8 micro-seconds (provision for alternate external pulse of 0.25us)
Antenna	
Reflector	10-foot parabolic
Beam Width	2.5 degrees
Polarization	Vertical, horizontal, right-hand circular, left-hand circular (selectable).
Feed	Nutating 30 cps
Nominal Gain	37 db
Receiving Section	
Frequency	2700 to 2950 mc
Intermediate Frequency	30 mc
Bandwidth	3 mc
Noise Factor	7 db
Minimum signal for automatic tracking	-98 dbm minimum
Maximum Range	2343.5 nautical miles
Automatic Range Tracking	
Rate	10,000 yards per second
Accuracy at maximum range	± 25 yards
Fast Slew	500,000 yds per second
Antenna Positioning System	
Elevation	
Tracking Range	20 mils below horizontal to 1580 mils above horizontal
Accuracy	1 mil at 3 deg/sec
Azimuth	
Tracking coverage	6400 mils
Accuracy	1 mil at 3 deg/sec
Velocity	10 degrees per second
Acceleration	5 deg/sec/sec

Table 6.3-1 Continued

Parameter	Specification
Tracking Modes	Automatic, Manual, Remote, PPI (within first 400,000 yds), Manual-Angle-Automatic Range, Automatic Angle-Manual Range, Passive Angle (without transmitting) azimuth and elevation
Scanning Methods	
Manual, Remote	Elevation or azimuth
Manual Angle-Automatic range	Raster
PPI	Continuous azimuth, manual elevation
Raster Scan	
Azimuth Coverage	10 degrees to 120 degrees, selectable in increments of 10 degrees
Elevation Coverage	To 20 degrees, selectable in 5 degree increments
Power Input (Average)	
Radar Set	16 kw
Facilities	30 kw
Data Outputs	Five (5) encoders to convert analog data (slant range, azimuth, elevation) to digital data (16-bits gray range, 19-bit gray) Synchro data (antenna positioning and readout) supplied as analog information Potentiometer data (slant range, horizontal range, altitude, north-south range, east-west range) supplied as analog information to plotting board.

Table 6.3-2 Performance Specifications on the AN/FPQ-6 and AN/TPQ-18 Tracking Radars

Parameter	Specification
Transmitter frequency	C-Band, tunable 5400 to 5900 mc in 243 kc increments
Peak RF power	3 megawatts
Average RF power	4.8 kilowatts
Range	32768 n.m. on 160 prf, 32512 n.m. on 640 prf; 500 n.m. for skin target of one square meter
Pulse repetition frequency	160 and 640 pps (basic), 1707 pps max
Pulse duration	0.25, 0.5, 1 and 2.4 μs
Pulse coding capability	5 pulses, 0.25 μs duration, spaced 1.0 μs 2 pulses, 1.0 μs duration, spaced 3 μs
Receiver frequency	5370 to 5930 mc
Receiver noise figure	8 db, with addition of parametric amplifiers noise figure is reduced to 4 db
Receiver bandwidth	4.8 mc to 0.5 mc, depending on pulse width
Intermediate frequency	30 mc
Receiver dynamic range	120 db, with programmed attenuation; programmed attenuation reduces received signal as target approaches, preventing receiver overload and degradation of track
Range Tracking Rate	20,000 yards/sec
Range slewing rate	240,000 yards/sec
Acceleration	10,000 g's at max bandwidth
Range Tracking Precision	3 yards RMS
Range tracking granularity	± 2 yards from short ranges to 32,000 n.m.
Acquisition data accuracy	± 5 n.m.

Table 6.3-2 Continued

Parameter	Specifications
Antenna Pedestal Features	
Antenna size	29-foot Cassegrainian, with 5-horn monopulse feed
Antenna beamwidth	0.4^{o}
Antenna gain	51 db
Antenna polarization	Vertical or circular
Antenna pedestal drive	Hydraulic
Antenna rotation azimuth	360^{o} Continuous
Antenna rotation elevation	-7^{o} to $+ 182^{o}$
Azimuth bearing	Hydrostatic
Angle tracking rates	Up to 28^{o} per second in both axes
Angle servo bandwidth	Adjustable from 0.1 cps to 4 cps
Angle tracking precision	0.05 mil, standard deviation
Acquisition Features	
Video integrator, C-scope & joy stick	C-scope reproduces scanning pattern of antenna; brightening of spot by video integrator indicates target to operator
Aux-Track	Aux angle tracking provides automatic angle tracking of either beacon or skin targets, and has a probability of 99.5% of locking-on in 0.2 seconds to target with signal-to-noise ratio of 10 db or greater
Angle Scans	
Circle	8 mils p-p
Spiral	5^{o} p-p
Raster	0.9^{o} Az by 8^{o} in El
Rectangular	8^{o} in EL with 0.3^{o} between beam centers in Az
Output Features	
Range	25-bit serial binary word, 2 yds per bit (any order)
Angle	19-bit single speed binary word; with output corrected for dynamic lag, 0.0125 mil/bit (any bit order); Synchros—1:1, 16:1, 36:1 available; Potentiometer—sine-cosine

Table 6.3-2 Continued

Parameter	Specification
Data Processing	
Maximum word length	32 bits
Memory capacity	8195 words
Add time	19.2 μs
Multiply time	134.4 μs
Read-in or Read-out time/ fit (memory)	12 μs
Read-in or Read-out time/ fit (buffer)	6.4 μs
Time to supply parallel data to user equipment after "read" pulse is applied	600 μs
Auxiliary Equipment	TV

Table 6.3.3 Performance Specifications of the AN/FPS-16 and AN/MPS-25 Tracking Radars

Parameter	Specification
Transmitting System	
Frequency	Fixed 5480 ± 30 mc tunable 5450 to 5825 mc
Peak power output	250 kw min for 5450 to 5825 mc 1 megawatt at 5480 ± 30 mc
Pulse repetition frequency	341, 366, 394, 467, 569, 682, 732, 853, 1024, 1280, 1364, and 1707 pps
Pulse width	0.25, 0.5, and 1.0 μs
Dynamic Range (Gain Control)	20 db
Duty Cycle	.001
Antenna	
Reflector	12 ft parabolic (FPS-16), 16 ft parabolic (MPS-25)
Beam width	1.2 degrees
Gain	43.5 db (FPS-16), 46 db (MPS-25)
Polarization	Vertical
Feed	4-horn Monopulse
Receiving System	
Frequency	5400 to 5900 mc
Intermediate Frequency	30 mc
Bandwidth	1.8 to 8 mc selectable
Noise Factor	11 db
Sensitivity	-99 dbm
Range	500 yds to 200 n.m.
Master Timing	81.959 kc
Automatic Range Tracking	
Rate	8,000 yards per sec
R. M. S. Error	7 yards at 1000 yards per sec
Manual Range Tracking	
Slew Rate	30,000 yards per sec
Aided Rate	Up to 8000 yards per sec

Table 6.3.3 Continued

Parameter	Specifications
Antenna Positioning System	
Elevation	
Tracking range	-10 degrees to + 190 degrees
Tracking rate	400 mils per sec
Accuracy	± 0.1 mils rms
Azimuth	
Tracking Coverage	360° continuous
Tracking rate	750 mils per sec
Accuracy	± 0.1 mils rms
Scan	Circular and sector
Power Input	100 KVA
Data Transmission	
Potentiometer	
Range	0 to 400,000 yds.
Azimuth	360° sine-cosine
Elevation	200° sine-cosine
Encoders	
Optical	13 lbs azimuth, elevation, range
Mechanical	5, 5 and 8 bits, azimuth, elevation, range
Digital Data Out	
Straight Binary	17 bits, azimuth and elevation 20 bits, range
Reflected Binary	18 bits, azimuth and elevation 21 bits, range
Appendix A	
Modification to extend range from 200 n.m. to 500 n.m.	
Electrical Characteristics	Replace 1707 μs PRF with 142 μs PRF Synchro data output changed from dual to three speed
Range	500 yds to 500 n.m.
Reference	Addendum 1 to Navaer 16-30 FPS 16-501
Modification to include Acquisition Display and Control system	
Electrical Characteristics	Full-range acquisition, interval gate acquisition and aided or manual acquisition
Reference	Addendum 7 to NAVNEPS 16-30 FPS 16-501

Table 6.3-4 Performance Specifications on the AN/MPS-26 Tracking Radar

Parameter	Specification
Radiating Characteristics	
Frequency	5450 to 5825 mc
Power	210 kw to 250 kw
Pulse Widths (adjustable in 0.04 microsecond increments from 0.2 to 1.2 microseconds)	Narrow: 0.25 microsecond, Wide: 1.0 microsecond
Duty cycle	0.001
PRF	320 or 640 pps
Multipulse capability	Up to five 0.25 microsecond pulses
Pulse Spacing	1.0 microsecond
RF line loss	1.5 db
Azimuth Tracking	
Range	Continuous
Rate	60°/sec, max
Acceleration	22.5°/sec/sec
Slew	60°/sec, max
Accuracy	0.5 mil
Elevation Tracking	
Range	-2° to +89.8°
Rate	30°/sec, max
Acceleration	22.5°/sec/sec
Slew	30°/sec, max
Accuracy	0.5 mil
Range Tracking	
Range	500 to 5 million yd
Rate	10,000 yd/sec
Acceleration	30g
Slew	500,000 yd/sec
Acquisition	±1000 yd acquisition gate
Accuracy	10 yd
Gate Widths	Narrow: 2.0 microseconds, Wide: 12.0 microseconds
Data Outputs	
Synchro, 60 cps	Azimuth: 1:1 speed and 36:1 speed Elevation: 1:1 speed, 64:18 speed and 36:1 speed Range: 2000 yd/rev; 50,000 yd/rev; 1 million yd/rev; 25 million yd/rev

Table 6.3-4 Continued

Parameter	Specification
DC Potentiometer	Azimuth: Sin-Cos 0.05% linearity Elevation: Sin-Cos 0.05% linearity Range: Linear, 0.01% linearity
Digital	Azimuth: 16-bit or 17-bit Elevation: 16-bit or 17-bit Range: 22-bit (1.22 yd/bit)
Designation (slave operation)	Azimuth: 1:1 speed Elevation: 1:1 speed Range: 50,000 yd/rev; 1 million yd/rev; 25 million yd/rev
Synchronization	May be synchronized from master range chain synchronizing signal
Antenna	
Diameter	10 ft
Polarization	Vertical, horizontal, or circular (Push-button selectable while tracking)
Feed	Nutating, 30°/sec, nonrotating
Crossover	1 db or 3 db, interchangeable
Efficiency	0.55
Beamwidth (at—3 db points)	1.5°
Gain (over isotropic radiator)	41 db
Side lobe levels	20 db down
Receiver	
Tuning Range	5400 - 5900 mc
Noise Figure	10 db max
Bandwidth, skin	Optimized for 1.0 microsecond pulses
Bandwidth, beacon	Optimized for 0.5 microsecond pulses
AFC hold-in	Skin: 7.5 mc; Beacon: 5400 - 5900 mc
Sweep range (skin and beacon)	±7.5 mc
Sensitivity	-100 dbm, or better
IF (skin and beacon)	30 mc
AGC (skin and beacon)	Fast and slow
Dynamic range (AGC)	93 db
STC	Skin and beacon
Ranging Crystal	81.959 kc dual, adjustable
Beacon delay	Adjustable -3 to +6 microseconds (-500 to +1000 yd)
Servo coasting	Angle and range
Physical configuration	Mobile, air-transportable, 20 ft or 40 ft trailers

Table 6.3-5 Performance Specifications on the Mod II Tracking Radar

Parameter	Specification
Reflector	
Diameter	10 ft
Gain	37 db
Beamwidth	2.5 inches
Beamcrossover	80% or 50%
Pointing Accuracy	± 1 mil
Feed System	
Type Scan	Conical
Type Feed	Notating
Polarization	Vertical, Circular, Horizontal
Scan Frequency	30 cps
Transmitter	
Frequency Range	2650 to 2850 mc
Frequency Accuracy	± 1.5 mc
Power	250 kw
Pulse Width	0.75 ms
Average Power	0.5 kw
Pulse Repetition Rate	1707, 1280, 1024, 852, 732, 682, 569, 467, 410, 366, 341, 205 pps
Receiver	
Sensitivity	-102 dbm
Noise Figure	7.5 db
Bandwidth	2 mc
IF Frequency (NF with Parometric Image Rejection)	30 mc
Coverage	500 min
Range	379 n.m.
Azimuth	360°
Elevation	-10° to 87°
Tracking Rates	8,000 yds/sec
Range	10,000 yds (ideal)
Azimuth	20°/ sec
Elevation	15°/ sec
Slewing Rates	
Range	20,000 yds/sec
Azimuth	20°/sec
Elevation	20°/sec

Table 6.3-5 Continued

Parameter	Specification
Range Accuracy	± 10 yds
Digital Data Output	
Encoder A Z	Optical Baldwin, 16-bit
Elevation	Optical Baldwin, 16-bit
Range	Mech Giannini, 20-bit
Analog Data Output	
Pots Azimuth	Nike (Sine, Cos)
Elevation	Nike (Sine, Cos)
Range	Analog Systems
Output Powertube	Magnetron
Range Tracking Gates	12.5 ms
Stability of Transmitter	± 5 mc

Table 6.3-6 Performance Specifications on the Milgo Model 4003 Cartesian-to-Polar Coordinate Converter

Parameter	Specification
Features	Outputs position external tracking equip such as radars, trackers, infrared sensors and optical trackers, in accordance with a target location
Inputs	Three varying DC voltages representing the X, Y and Z coordinates of a target
	Reference voltage varying between ±140 volts representing one of two scales selected by the customer: X = D cos E sin A Y = D cos E cos A and Z = D sin, where D is slant range to the target E is elevation angle, and A is azimuth angle measured clockwise from true North
Outputs	Azimuth output consists of a 2 speed (36.1) synchro system comprised of 2 size 23 synchro transmitters. One revolution of the coarse transmission represents 360°; of the fine, 10°
	Elevation output consists of a 2 speed (36.1) synchro system consisting of 2 size 23 synchro transmitters. One revolution of the coarse transmission represents 360°; of the fine, 10°
	Range output consists of a DC voltage corresponding to the selected range scale. One revolution of the coarse transmitter represents 25,000,000 yds; of the fine, 1,000,000
Power Requirements	920 watts, 115 ± 10 volts, 60 ± 5 cps
	The requirements indicated are for the basic C-P Converter. With the addition of auxiliary computing elements, the require-

Table 6.3-6 (Continued)

Parameter	Specification
	ments will increase to a maximum of 17 amperes at full load.
Rack Dimensions	24" x 22" x 74"
Basic Unit	Contains 12 contact stabilized DC amplifiers, control unit, 1 data smoothing unit, and 2 resolver units.

Table 6.3-7 Performance Specifications on the Milgo Model 4004 Polar-to-Cartesian Coordinate Converter

Parameter	Specification
Features	Transforms radar potentiometer outputs into analog voltages for use in computing and tracking systems, i.e., outputs supplied will position a second tracking radar in accordance with a target location No fungus nutrients are employed; all transformers are hermetically sealed against moisture in accordance with MIL-T-27-Grade #1 "Transformers and Inductors."
Inputs	Requires load resistances as specified below; different load resistances can be used to meet special requirements
Range Linear Potentiometer Resistance:	
Maximum	50,000
Minimum	10,000
Maximum Wiper Series	10,000
Minimum Wiper Series	0
Load Resistance	100,000 to 1 megohm
Elevation Sine-Consine Potentiometer Resistance:	
Minimum	10,000 per quadrant
Maximum Wiper Series	10,000 each
Minimum Wiper Series	0 each
Load	100,000 to 1 megohm
Azimuth Sine-Cosine Potentiometer Resistance:	
Minimum	10,000 per quadrant
Maximum Wiper Series	10,000 each
Minimum Wiper Series	0 each
Load	100,000 to .1 megohm
Outputs	Consist of 3 analog voltages representing the X, Y and Z coordinates of a target. Voltages vary between ± 140 volts and are capable of driving a 5000 load.

Table 6.3-7 Continued

Parameter	Specification
Power Requirements.	115 ± 10v, single phase 60 ± 5 cps 7.25 amperes Load can be split across a 120/240v single phase line, or 2 phases of a 3 phase 120v system. Current requirements indicated are for the basic P-C Converter. With the addition of auxiliary computing elements, the requirements will increase to a maximum of 17 amperes at full load.
Rack.	Developed in accordance with MIL-E-4158A "General Requirements for Electronic Equipment, Ground."
Rack Dimensions:	24" x 22" x 74"
Rack Weight:	approximately 400 pounds

Table 6.3-8 Performance Specifications on the Milgo Model 4005-R Digital-to-Analog Receiver

Parameter	Specification
Features	13 digit binary system, resolution of one binary bit; 480 bps, 10 pps rate; accuracy of 0.025 percent
Inputs	Digital binary pulse train of 480 bps, 10 frames per sec for each 48 bit code word Each input pulse is a 1920 cps tone burst of 2.08 millisecond duration in a sinusoidal envelope Externally supplied 140v referency system, if desired
Outputs	3 analog voltages representing X, Y and H (or Z) coordinates of a target 6 auxiliary relay command signals $\pm$ 140v internally generated reference system, if desired
Power Requirement	Operates from single phase, 120 $\pm$ 10vAC, 60 $\pm$ 5 cps at 14 $\pm$ 1 amperes
Rack Dimensions	24" x 22" x 74"
Rack Weight	Approximately 600 pounds All rack wiring is accessible through a rear door. A filtered cooling system keeps the unit dust free. MIL-E-4158B "General Requirements for Electronic Equipment, Ground" and MIL-Q-9858C "Quality Control Over System Requirements" have been used as guides in design and construction. No fungus nutrients are employed. All transformers are hermetically sealed against moisture.

Table 6.3-9 Performance Specifications on the Milgo Model 4005-T Analog-to-Digital Transmitter

Parameter	Specification
Features	13 digit binary system with a resolution of one binary bit, 480 bps, 10pps rate, accuracy of 0.025 percent
Inputs	3 analog voltages representing the X, Y and Z or H coordinates of a target 6 auxiliary bits as coding and indentification information Externally supplied 140v reference, if desired
Outputs	Digital data of 10 frames per sec of each 48 code word at a 3 kc band width Each output pulse is a 1920 cps tone burst of 2.08 millisecond duration in a sinusoidal envelope Output transmission may be radio link, submarine cable, telephone line, microwave, other communication methods
Power Requirements	Operates from single phase. 120 $\pm$10vAC, 60 $\pm$ 5 cps at 14 $\pm$ 1 amperes
Rack Dimensions	24" x 22" x 74"
Rack Weight	Approximately 600 pounds All rack wiring is accessible through a rear door. Filtered cooling system keeps the unit dust free. MIL-E-4158B "General Requirements for Electronic Equipment, Ground," and MIL-Q-9858C "Quality Control System Requirements" have been used as guides in design and construction. No fungus nutrients are employed. All transformers are hermetically sealed against moisture.

Table 6.3-10 Performance Specifications on the Milgo Model 4008-1B Data Transmitter for Verlort Radar

Parameter	Specifications
Features	Self-contained and completely modular; all major components are comprised of individual plug-in units; temperature control is provided by a filtered, forced-air cooling system
Inputs	Accepts parallel Gray digital data from a Verlort radar; Gray inputs are converted to straight binary and data is reformatted for transmission over 3 kc communication facilities to a remote receiver
Outputs	Produces 10 complete word frames of information per sec, each divided into 100 time slots including intelligence; data consists of 19 bits of range, 16 bits of azimuth and 16 bits of elevation information
Power Requirements	120 volts, 60 $\pm$ 5 cps at less than 7 amperes
Rack Dimensions	74" x 22" x 22"
Rack Weight	Approximately 560 pounds

Table 6.3-11 Performance Specifications on the Milgo Model 4008-1B Data Transmitter for the AN/FPS-16 Radar

Parameter	Specification
Features	Operates either on range time (10 pps and 1 kc) or from internally generated 10 pps and 1 kc signals; self-contained, completely modular, with a filtered, forced-air cooling system
Inputs	Accepts digital data from FPS-16 Radar Receiver; time data is multiplexed with radar data and then transmitted at ten word frames per sec, each divided into 100 time slots; intelligence is carried by a code comprised of the presence or absence of the bursts in each time slot
Outputs	Consist of tone bursts of approximately 2 kc carrying 17 bits of azimuth, 17 bits of elevation, 20 bits of range, and 20 bits of time; a 10 pps sample pulse and 21 radar shift pulses at 250 pps are also provided to read data into the transmitter
Power Requirement	120 volts, 60 $\pm$ 5 cps at 7 amperes
Rack Dimensions	74" x 22" x 22"
Rack Weight	Approximately 470 pounds.

Table 6.3-12 Performance Specifications on the Milgo Model 4008-2A Real-Time Date Receiver

Parameter	Specification
Features	Has facilities for controlling an associated tape recorder; data may be received in real time or as pre-recorded data on tape. Unit is self-testing, self-contained and completely modular, requiring no external power other than a 115v AC source. Temperature control is provided by a filtered, forced-air cooling system
Inputs	Accepts radar data in the form of tone bursts and converts this data into pulses for computer evaluation; radar data is received over submarine cable or other communications facilities; receiver accepts 17 bits of azimuth, 17 bits of elevation, 20 bits of range, and 20 bits of time information at 10 samples per second
Outputs	Consist of 4 parallel words supplied to the computer with copy and disconnect instructions at the completion of transfer; total transfer time is approximately 1.5 milliseconds
Power Requirements	115 volts, 60 $\pm$ 5 cps at approximately 8 amperes
Rack Dimensions	74" x 22" x 22"
Rack Weight	Approximately 500 pounds.

Table 6.3-13 Performance Specifications on the Milgo Model 165 Digital-to-Teletype Converter

Parameters	Specification
Features	Adaptable to commercial or military applications; transmits data to several locations simultaneously; accepts HSD; output teletype speed adjustable - 60 to 100 wpm; self-testing facilities; solid state design; modular construction
Inputs	Accepts parallel or serial data (pulses or levels), Gray coded, straight binary, binary-coded decimal data of any combination, from radars, encoders (photo optic or brush) storage registers, computers, tape recorders, etc.
Outputs	Transmits coded or non-coded data using teletype code via teletype transmission, to teletype printers, computers, plotting boards, paper tape punchers, card punchers, magnetic tape units, etc.
Power Requirements	Operates from single phase, 120 $\pm$ 10VAC, 60 $\pm$ 5cps at less than 5 amperes
Rack Dimensions	24" x 22" x 74"
Rack Weight	Approximately 475 pounds All rack wiring is accessible through a rear door; filtered cooling system keeps the unit dust free.

Table 6.4-1 Performance Specification on the MSFTP-1 Ground Station

Parameter	Specification
Signal Inputs	Serial input PCM TLM signals from receivers, simulators, or tape playback (forward or reverse) as follows: RZ pulse train, NRZ type C, NRZ type S, NRZ type M, Split phase.
Bit Rates	10 to 1,000,000 bps for NRZ input; 5 to 500,000 bps for RZ or split phase input
Word Length	Variable, up to 64 bits; words may be built up of sub-words or syllables
Subcommutation	Capable of subcommutation lengths up to 200 channels
Supercommutation	Capable of handling supercommutated rates which are harmonies of the frame rate
Primary Frame Length	Up to, but not restricted at, 1096 bits and 520 channels
Primary Frame Synchronization	Code patterns from 7 to 64 bits in length
Programming	Patchboards, 4 separate pre-patched formats selectable by switch
Sub Frame Synchronization (for sub-decommutation)	ID words up to 8 bits, or "recycling code" method
Word Synchronization	Word sync codes of 1, 2, or 3 bits may be used
System Outputs Displays	Monitor displays; binary, and decimal displays to permit monitoring of any channel from frame or subframe
Data Outputs Serial data output	Regenerated serial bit stream for distribution

Table 6.4-1 Continued

Parameter	Specification
Parallel data outputs	64-bit parallel data output with msb in line, and zeros inserted for missing bits when words are shorter than 64-bits; 8-bit parallel data output with msb in line, and zeros inserted for missing bits when words are shorter than 64-bits; BCD multiplex—all words in parallel binary coded decimal; a total of 10 BCD stores are provided; any channel may be decommutated and transferred to any of 100 binary-to-analog converters; 60 positions of 4-bits each are available for storage of ON/OFF data from any desired channel.
Status Signals	Available for identification and synchronization of data outputs are synchronization status signals; bits/word numbering, parallel binary number output; word numbering—numbers indicating location of channels with primary or subframes (binary and BCD outputs); frame numbering (binary and BCD outputs); 100 channel transfer commands; on-off logic signals indicating format in use; 4 clock timing pulse trains from bit synchronizers, each 90^{o} apart in phase; complement and reset from bits/word counter, words/frame counter, and frames/subframe counter; transfer command pulse; parity bit.

Table 6.4-2 Performance Specifications on the Nems-Clarke Model 1455A Ultra-High Frequency Telemetry Receiver

Parameter	Specification
Frequency Range	215 to 260 mc
Input Impedance	50 ohms nominal
Noise Figure	Less than 8 db
IF Rejection	60 db
Image Rejection	48 db
1st Local Oscillator	Crystal or VFO; frequency determined by plug-in unit.
2nd Local Oscillator	Tunable, ± 150 kc
IF Frequency	1st, 30 mc; 2nd, 5 mc
IF Bandwidth	Plug-in demodulator modules in bandwidths from 10 kc to 1.5 mc; most modules contain 3 independent demodulation modes, a Foster-Seeley FM discriminator, an AM envelope detector, and a phase-lock detector (with IF bandwidth from 30 to 500 kc)
Signal-to-noise Ratio	
AM Rejection	
Detector	Determined by IFM plug-in unit type
Video Outputs	0-11 v across, 500K ohms min load; video frequency, less than 100 ohms source impedance. 1 cps to 1.2 mc, ± 3 db (will pass 1 cps square wave with less than 15% tilt)

Table 6.4-3 Performance Specifications on the Nems-Clarke Model 1434 Ultra-High Frequency Telemetry Receiver

Parameter	Specification
Frequency Range	215-260 mc
Input Impedance	50 ohms, nominal
Noise Figure	Less than 8 db
IF Rejection	Greater than 60 db
Image Rejection	Greater than 48 db
1st Local Oscillator	Crystal controlled
2nd Local Oscillator	Tunable over a frequency range about the second IF frequency of ± 150 kc
IF Frequency	First IF, 30 mc Second IF, 5 mc
IF Bandwidth	Wide band, 50 kc bandwidth at 3 db down Attenuation, ± 150 kc from center frequency greater than 60 db Narrow band, 100 kc bandwidth at 3 db down Attenuation, ± 250 kc from center frequency greater than 60 db
Signal-to-noise Ratio	50 kc passband, 30 db for 1.0 μv of input carrier, when carrier is modulated ± 20 kc at a 1000-cps rate 100 kc passband, 30 db for 1.0 μv of input carrier, when carrier is modulated ± 20 kc at 1000-cps rate
AM Rejection	50% AM reference carrier deviation, ± 50 kc measured on 100 kc bandwidth. 400 cps to 10 kc, greater than 30 db
Dectector	Linear to better than one percent over a bandwidth of ± 50 kc
Video Output	Sensitivity, 0.3 volt peak-to-peak per kc of deviation. Minimum frequency response, 300 cps to 15 kc, within 3 db

Table 6.4-4 Performance Specifications on the Nems-Clarke Model 1432 Ultra-High Frequency Telemetry Receiver .

Parameter	Specification
Frequency Range	215 to 260 mc, determined by plug-in crystals or variable frequency tuning unit (Nems-Clarke VF-1400A)
Input Impedance	50 ohms, nominal
Noise Figure	Less than 8 db
IF Rejection	Greater than 60 db
Image Rejection	Greater than 48 db
1st Local Oscillator	Crystal controlled or variable frequency tuning unit (Nems-Clarke VF-1400A) controlled, stability 0.001%
2nd Local Oscillator	25 mc tunable over a frequency range of ±150 kc
IF Frequency	First IF, 30 mc; second IF, 5 mc
IF Bandwidth	Wide band 500 kc bandwidth at 3 db down attenuation, ±500 kc from center frequency, greater than 60 db Narrow band, 100 kc bandwidth at 3 db down; attentuation, ±250 kc from center frequency, greater than 60 db
Signal-to-noise Ratio	500 kc passband, 40 db for 1.5 uv of input carrier when carrier is modulated ±100 kc at a 1000-cps rate; 100 kc passband, 40 db for 1.7 μv of input carrier when carrier is modulated ±100 kc at a 1000-cps rate. The above s/n ratios are measured with a 2500-cps RC low pass filter at receiver video output.
AM Rejection	50% AM (reference carrier deviation, ±100 kc) 400 cps to 10 kc, greater than 50 db 10 kc to 30 kc, greater than 35 db 30 kc to 80 kc, greater than 25 db

Table 6.4-4 (Continued)

Parameter	Specification
Detector (Model 1432)	Linear to better than one percent over a bandwidth of ±150 kc
Video Output	Sensitivity, 0.07 v (min) per kc of deviation with output control at max frequency response; 10 cps to 100 kc (ac-coupled), within 3 db
Power Input	117 VAC, 60 cps, approx 150 w (400 cps available with special blower motor)

Table 6.4-5 Performance Specifications on the Nems-Clarke Model 1415 Ultra-High Frequency Telemetry Receiver

Parameter	Specification
Frequency Range	215 to 260 mc
Input Impedance	50 ohms, nominal
Noise Figure	Less than 8 db
IF Rejection	Greater than 60 db
Image Rejection	Greater than 48 db
1st Local Oscillator	Crystal controlled
2nd Local Oscillator	Tunable over a frequency range of ± 50 kc about the second IF of ± 150 kc
Intermediate Frequency	First IF, 30 mc Second IF, 5 mc
IF Bandwidth Wide Band Narrow Band	 180 kc at 3 db down 500 kc at > 60 db down 50 kc at 3 db down 300 kc at > 60 db down
Signal-to-noise Ratio 100 kc Passband 50 kc Passband	 40 db, for 1.5 μv of input carrier when carrier is modulated ± 50 kc at the rate of 1.0 kc 30 db, for 1.0 μv of input carrier when carrier is modulated ± 20 kc at the rate of 1.0 kc
AM Rejection	0.4 to 10 kc, > 30 db
Discriminator	Linear to better than one percent over a bandwidth of ± 50 kc
Video Output Sensitivity Deviation	 Min 0.3V (peak-to-peak)/kc deviation Within 3 db at 15 cps to 15 kc

Table 6.4-6 Performance Specifications on the Nems-Clarke Model 1412 Ultra-High Frequency Telemetry Receiver

Parameter	Specification
Frequency Range	215 to 260 mc, determined by plug-in crystals or variable frequency tuning unit (Nems-Clarke VF1400A)
Input Impedance	50 ohms, nominal
Noise Figure	Less than 8 db
IF Rejection	Greater than 60 db
Image Rejection	Greater than 48 db
1st Local Oscillator	Crystal controlled or variable frequency tuning unit controlled, stability 0.001% (Nems-Clarke VF1400A)
2nd Local Oscillator	25 mc, tunable over a frequency range of ± 150 kc
Intermediate Frequency	1st IF, 30 mc; 2nd IF, 5 mc
IF Bandwidth	Wide Band 0.5 mc at 3 db down 1.0 mc at 60 db down Narrow Band 0.1 mc at 3 db down 0.5 mc at 60 db down
Signal-to-noise Ratio 0.5 mc Passband	100:1, for 2 uv of input carrier when carrier is modulated ± 100 kc at the ratio of 1.0 kc
0.1 mc Passband	100:1, for 1.5 uv of input carrier when carrier is modulated ± 50 kc at the rate of 1.0 kc
AM Rejection (± 100 kc ref carrier dev)	0.4 to kc, 6 db 10 to 30 kc, 50 db 30 to 80 kc, 35 db

Table 6.4-6 Continued

Parameter	Specification
Detector (FM Discriminator Model 1412)	Linear to better than one percent over a bandwidth of ± 150 kc
Video Output Sensitivity (control at max freq response)	Minimum of 70 mv/kc deviation
Deviation (ac-coupled)	Within 3 db at 10 cps to 100 kc
Power Input	Approx 150 watts, 117 VAC, 60 cps (with special blower motor, 400 cps is optional)

Table 6.4-7 Performance Specifications on the Nems-Clarke Model DCA-510 Diversity Combiner

Parameter	Specification
Receiver Outputs Accepted	Either 1 or 2, Nems-Clarke Model 1415 or 1434 Telemetry receivers
Type Signal Accepted	IRIG FM/FM Subcarrier Nos. 5, 6, 7 and 12
Noise Sampling Frequency Range	3.5 to 7.0 kc
Input level	40 mv/kc (for approx 10% max difference between inputs), 8 V RMS is maximum input
Input Data Phase Shift	45 degrees maximum between any two inputs
Overall Gain	Variable, from -6 to +6db
Maximum Output Level	10 V RMS, with 500 ohms load
Overall Frequency Response	$\pm$ 2 db, from 100 cps to 200 kc
Distortion	Less than 1%
Signal-to-noise Ratio Improvements for Equal Input Signal-to-noise ratios	2 to 3db for two inputs, when phase shift between inputs is less than 45 degrees

Table 6.4-8 Performance Specifications on the Model PR-203 Preamplifier

Parameter	Specification
Type	Low noise figure pre-amplifier
Bandwidth	20 mc
Operating Center Frequency	260 to 300 mc
Uniformity of Response	± 1.5 db of midband response
Gain	26 db minimum in passband
Impedance	Designed to operate into 50-ohm load
Noise Figure	4.0 db max, within ± 10 mc of center frequency
Power Consumption	57 watts

Table 6.4-9 Performance Specifications on the Arnoux Model TDS 90/90 Decommutator

(To be supplied later)

Table 6.4-10 Performance Specifications on the Bendix Model TDA-102 Dual Channel Discriminator

(To be supplied later)

Table 6.4-11 Performance Specifications on the Bendix Model TDA-300 Discriminator

(To be supplied later)

Table 6.4-12 Performance Specifications on the Defense Electronics Model TPA-1 Wide Band Preamplifier

(To be supplied later)

Table 6.5-1 Performance Specifications on the Collins-Alpha Model AN/FRW-2 Ultra-High Frequency Command Control Radio Transmitter

Parameter	Specification
Frequency Range	406 mc to 549 mc
Power Output	600 watts minimum over entire range
RF Antenna Output Impedance	50 ohms
Number of Channels	144
Channel Spacing	1 mc
Modulation Input Impedance	560 ohms
Number of modulating tones	20
Modulation Tone-Frequency Range	7.5 kc to 73.95 kc
Simultaneous Keying	6 channels
Type Modulation	FM
Maximum Carrier Deviation with Modulation	$\pm$ 300 kc
Primary Power Requirements	4065 VA, 200 to 230 VAC, 55 to 65 cps
Equipment supplied for each set 2 ea, KY-171/VRW Coder 2 ea, R-669A/VRW Receiver 2 ea, KY-172/VRW Decoder 2 ea, 560A/FRW-2 Radio Transmitter	

Table 6.5-2 Performance Specifications on the Collins-Alpha Model 240D-2 Ultra-High Frequency Power Amplifier

Parameter	Specifications
Power Input	55 kva, 208 volts ± 10%, 50 to 63 cps; 3-phase, 4-wire
Frequency range	406 to 549 mc
Power output	10 kw
Number of channels	144
Channel spacing	1 mc
Number of modulating tones	20

Table 6.5-3 Performance Specifications on the Remote Site Digital Command System Unit

Parameter	Specification
Use	Accept command program; process and store information in digital form; provide display and control facilities; and produce a phase shift-keyed tone for modulation of the command transmitter.
Inputs	
Serial	Teletype, 60 or 100 wpm High Speed, 1000 bps
Parallel	Manual, via 40 contact pushbuttons on main control panel On-site computer
Memory Capacity	512 40-bit words (expandable to 1024 x 60 bits)
Gemini priority	Words 1-32
Gemini command	Words 33-182
Agena priority	Words 257-288
Agena command	Words 289-438
Agena velocimeter	Words 439
Test Word 1	Word 192
Test Word 2	Word 193
Transmit*	
Bit rate	200 bps (expandable to 100K bps)
Sub-bit rate	1K bps (expandable to 500K bps)
Data selection	
Command	1-150 words per system
Priority	1-32 words per system
Clock	TR, TF, TX
Velocimeter	Automatic, manual
Control and Display	All controls capable of being remoted All operations initiated by Program Start pushbutton
Displays	Address of all valid words stored in memory Address of all words selected for transmission or display Input/Output Buffers A and B All Clocks (7) Difference between ground and capsule TR Difference between ground and capsule TF All modes and status conditions All error conditions.

* Redundant paths from memory to antenna; automatic switch-over if transmitting path fails; retransmission of non-valid words.

Table 6.5-4 Performance Specifications on the Master Digital Command System Unit

(To be supplied later)

Table 6.5-5 Performance Specifications on the Downrange Up-Data-Link Unit

(To be supplied later)

Table 6.6-1 Performance Specifications on the GATES Model CS-2029 High Frequency Voice Transmitter

Parameter	Specification
Type	Xtal-controlled, dual channel, capable of operating on either of two pre-set channels
Primary power input	100% sinewave modulation - 1725 va Normal speech modulation - 1400 va No modulation - 1100 va Standby - 250 va
RF Power Output	14-26 mc, 250 w; 26-31 mc, 200-225 w
Noise	-50 db or more at 100% modulation
Output Impedance	52 ohms
Crystal Frequency	one-half operating frequency
Frequency Stability	0.0005%
Frequency Range	14-31 mc
Modulation	high level Class B
Audio Frequency Response	± 2 db 300-3500 cps -40 db or more at 100 - 60 db

Table 6.6-2 Performance Specifications on the Radio Receptor Model AN/GRT-3 Ultra-High Frequency Transmitter

Parameter	Specifications
Transmitter	Radio Receptor Model T-282/GR, single Channel
Modulator Power Supply	Radio Receptor Model MD-141A/GR
Frequency Range	225 to 399.9 mc (tunable)
Type of Frequency Control	Quartz crystal
Power Output	100 watts into a 50 ohm load
Modulation Input Circuit	50 ohm (carbon microphone input) and 600 ohm (audio line input)
Temperature Range	-29° C (-20°F) to +55°C (+131°F)
Nominal Power Output	100 w
Primary Power Requirements under Peak Operating Conditions	105/125 or 210/250 volts, 50/60 cycles, 1500 w

Table 6.6-3 Performance Specifications on the Collins Radio Model R-278B/GR Ultra-High Frequency Voice Receiver

Parameter	Specification
Frequency Range	225.0 to 399.9 mc
No. of Operating Frequencies	1750 spaced at 0.1 mc intervals
No. of Preset Channels	10 selected remotely plus 1 selected locally
Channel Change Time	Not more than 5 seconds
Type of Frequency Control	Quartz crystals
No. of Crystal Units	38
Type of Receiver	Triple-conversion superheterodyne with automatic tuning, automatic noise limiting, delayed and amplified volume control and carried-operated relay circuits
Sensitivity	At maximum setting of the "RF GAIN" control, two 6 microvolt signals with 30% modulation at 1000 cps will produce not less than 1.0 watt output at not less than 10 db signal-to-noise ratio
Selectivity	Bandwidth not less than 65 kc at 6 db attenuation; not more than 185 kc at 60 db attenuation
Frequency Stability	$\pm$ 10 kc
Image Frequency Rejection	More than 60 db below input signal level
Intermediate Frequency Rejection	More than 80 db below input signal frequency level
Types of Reception	Voice amplitude-modulated radio-telemetry; Tone; MCW

Table 6.6-3 Continued

Parameter	Specification
Input Impedance	52 ohms
Output Characteristics	3 watts into 600 ohm balanced load
Audio Frequency Responses	
Broad	Flat within 4 db from 200 to 20,000 cps
Narrow	Frequency (Cycles) — DB Attenuation 200 — greater than 10 400 — less than 5 1000 — 0 3000 — less than 5 5000 — greater than 10
Distortion	Less than 5% at 30% modulation and 3 watts output
Power Requirements under Normal Operation	115 or 230 volts, 50/60 cps, 385 watts first 10 minutes, 265 watts after 10 minutes
Power Consumption	350 watts

Table 6.6-4 Performance Specifications on the Collins Model R-390A/URR Ultra High Frequency Voice Receiver

Parameter	Specification
Performance	High, stable, general purposed, fixed and mobile service
Type of Circuit	Triple-conversion superheterodyne, amplitude modulater on eight lowest frequency bands; double-conversion superheterodyne on all other bands
Frequency Range	0.5 to 32 mc
Types of Signals Received	cw, mcw, voice, single sideband, frequency-shift keying
Type of Tuning	Continuous (frequency read directly on counter-type indicator)
Audio Power Output	
600 ohm Unbalanced Line	500 mw, minimum
600 ohm Balanced Line	10 mw, minimum
Headphones	1 mw, minimum
I-F Selectivity	100 cps to 16 kc bandwidth in six steps
Power Consumption	225 watts

Table 6.7-1 Performance Specifications on the TLM-18 Antenna System

Parameter	Specification
Antenna	
Reflector diameter	60 feet
Frequency band	216 to 245 mc
Gain above Isotropic Radiator	28 db
Polarization	Circular: axial ratio 1.26 or better
Scan Frequency	10 cps
Beam width to H.P. points	4.6 degrees
RF Preamplifier and Multicoupler	
Frequency band	216 to 245 mc
Gain	30 db nominal
Noise figure	3 db
Telemetry outputs for data	8
Output impedance	50 ohms
Isolation (between outputs)	30 db min
Response	Within 3 db of max over specified band
Tracking Receiver	
Frequency band	216 to 245 mc
Frequency stability	Crystal-controlled
Gain	130 db
Noise figure	7 db
IF bandwidth	300 kc
Scan Frequency filter (B.P.F.)	6 to 14 cps
Servo System (Manual or Automatic Tracking)	
Over-all tracking accuracy at 6°/sec	0.75 degree
Tracking and slew rates (el. and az.)	10°/sec max
Acceleration rates (el. and az.)	5°/sec/sec max
Elevation tracking limits	
Automatic	-1 to +86 degrees
Manual	-1 to +92 degrees
Elevation rate limit switch	Adjustable -1 to +15 degrees
Limited elevation tracking rate	3°/sec from ERL switch setting to -1°
Azimuth tracking limits	None (Continuous)
Acquisition signal	1.5 microvolts at antenna terminals

Table 6.7-2 Performance Specifications on the 9-Turn Quad-Helix Antenna Array

Parameter	Specification
Type	Four 9-turn helices mounted on a 12-foot square ground plane. Each individual element can be rotated 30 degrees about its axis to vary the RF phase.
Frequency Band	225-330 mc
Gain (Over a circularly polarized isotropic radiator)	18 db Min.
Polarization	Circular
Beamwidth Elevation Azimuth	 20 degrees 20 degrees
Axial Ratio	2 db
VSWR	1.5:1
Impedance	50 ohms
Weight	300 Lbs.
Size	12 ft. Square with 6.5 ft. Individual circular ground screens
Side Lobes	Sum Channel (10 db Principal Plane)

Table 6.7-3 Performance Specifications on the Canoga Model 8417 (Simplified Agave) Antenna Pedestal

Parameter	Specification
Mounting	12-ft. square ground plane, with pedestal adapter
Elevation Support Assembly	Secured directly to antenna X-frame assembly
Elevation*	-10 to + 110 deg
Azimuth*	-270 to + 270 (with use of cable wrap)
Actuation of Electrical Limit Switches	Switches are actuated at least 5 degrees before the mechanical limits are reached.

* Spring-Loaded mechanical stops prevent excessive rotation in either axis.

Table 6.7-4 Performance Specifications on the Simplified Model AN/SCR-584 Agave Antenna Pedestal

Parameter	Specification
Elevation	-10 to +110 deg
Elevation housing synchro assembly	Accommodates 3 one-speed synchros and one 6 4:18 speed synchro
Azimuth Compartment	Includes special electrical and mechanical limit stops
Azimuth	Max. rotation of 540 degrees (A cable wrap extends into the pedestal adapter, then up to the terminal strips in the azimuth compartment)
Limit Switches	Limit switches in the elevation and azimuth compartments provide electrical braking 10 deg before mechanical stops

Table 6.7-5 Performance Specifications on the Canoga 18 Crossed-Dipole-Element Telar Antenna

Parameter	Specification
Frequency	215 to 260 mc
Gain (over circularly polarized isotropic radiator)	18 db min
Beamwidth	
Elevation	15°
Azimuth	22°
Polarization	Linear or circular
Axial ratio	2 db
VSWR	1.5:1
Impedance	50 ohms
Weight	600 lbs
Size	12 ft. x 18 ft., fan-beam array
Side-lobe levels	
Sum channel, principal plane	16 db
Difference channel, principal plane	16 db

Table 6.7-6 Performance Specifications on the Model TAA-2 Automatic Tracking Antenna

Parameters	Specification
Reflector	85-ft. parabolic
Gain	25.5 db to 53 db
Frequency	100 to 2300 mc
Polarization	Right and Left circular simultaneous
Direction Sensing	Conical scan
Maximum Tracking Speed	10 deg/sec
Nominal RMS Auto-Tracking Error	0.2 deg

Table 6.8-1 Performance Specifications on the UNIVAC Model 1218 Remote Site Data Processor

Parameter	Specification
Type	On Site Data Processor UNIVAC 1218 General-purpose, medium-scale, solid-state, parallel.
Memory	Magnetic core 1.8-microsecond access time 4-microsecond read-write cycle time 18-bit word length, parallel transfers Available word sizes: 4096, 8192, 16,384, (32,768 optional) Certain locations are assigned in the first 4096 words for channel input and output control words, channel interrupt locations, and index registers. All memory locations are available without indirect addressing. A boot strap of 32 words of NDRO storage is provided.
Arithmetic	Organization: 18 bit, parallel, ones' complement, integer, binary Registers: Two 18-bit, addressable Functions: Arithmetic operations including double length add and subtract Logical and bit manipulation Instruction Execution Times: Add, Subtract, Logical 8 usec Multiply 38 usec (average) 48 usec (maximum) Divide 48 usec (maximum) Add, double length 12 usec Compare/Mask Compare and Branch 12 usec Register shifts: right, left, single, double (4 + 0.67n) usec where n = number of places shifted. Instruction times represent total execution including instruction and operant acquisition. Whenever address modification is desired, add four microseconds.

Table 6.8-1 Continued

Parameter	Specification
Control	Instruction organization: Single Address Address modification: Via eight memory contained Index Registers
Input/Output	Channels: Four input and four output or eight input and eight output channels are available. Each channel provides 18 parallel data lines plus necessary control lines. Channels can be paired to form 36-bit dual channels. Buffered Transfers: All input/output transfers are fully buffered, do not require program attention, and operate asynchronously at the rate required by the external device. Control words guide the active buffers by defining the memory location, buffer direction, and monitor. Operating Modes: Normal Single Channel - 18-bit parallel data transfers. Normal Dual Channel - 36-bit parallel data transfers. Externally Specified Index (Dual Channel) - 18-bit parallel data transfers with data storage index address specified by external device; can be used to automatically multiplex data to or from unique buffer locations. Intercomputer Single Channel - 18-bit parallel data transfers allow communication with other UNIVAC 1218 Computers (direct cable connection). Intercomputer Dual Channel - 30/36-bit parallel data transfers allow communication with the UNIVAC 1218, 1206, 1107, and 490 Computers; or with the CP642A/USQ-20(v) Computer and other NTDS equipment (direct cable connection). Transfer Times: Maximum Input/Output Transfer Rate: 100kc, 18-bit-words 16 u seconds per 18-bit word (input or output) 20 u seconds per 30/36-bit word (input or output)

Table 6.8-1 Continued

	Interrupts: 33 unique interrupts are provided as follows: 1 Synchronizing Interrupt (not channel associated) 8 External Interrupts (one per channel) 8 External Function Monitor Interrupts (one per channel) 8 Output Monitor Interrupts (one per channel) 8 Input Monitor Interrupts (one per channel) Priority: Priority of interrupts is according to function as listed above. Sub-priority is established according to channel number 7-0. Program Control: Eighteen program instructions are devoted to the control of Input/Output, providing positive control and a high degree of sophistication in programming. Peripheral Devices: Input/Output Console - provides a paper tape reader (300 cps), paper tape punch (110 cps), and alpha/numeric keyboard and page printer Magnetic Tape Systems - compatible with UNIVAC formats or with 200 and 556 bpi systems at 62.5 kc High Speed Line Printer - provides alpha/numeric printing and 120 columns Communications Units - provide data handling capabilities for telegraph or telephone line bit rates Magnetic Drum Storage - is available for up to 786,432 36-bit words per drum; drums can be multiplexed Other Input/Output devices are avilable to meet standard or special requirements.
Environmental Requirements	General Requirements: MIL-E-16400D (Navy) Interference: MIL-I-16910A Enclosure: MIL-STD-108D Shock: MIL-S-901 Vibration: MIL-STD-167 Temperature: 0^{o} to $50^{o}C$ Humidity: to 95%
Power Requirements	115 volt $\pm$ 10%, 1-phase, 60 cps, 150 watts maximum 115 volt $\pm$ 10%, 3-phase, 400 cps, 1500 watts maximum

Table 6.8-1 Continued

Repertoire of Instructions

Code	Symbol	Description	Time μs
02	CL	Compare Y	8
03	CLX	Compare Y+B	12
04	SS	Masked Substitute Y	8
05	SSX	Masked Substitute Y+B	12
06	CM	Masked Compare Y	8
07	CMX	Masked Compare Y+B	12
10	EU	Enter AU, Y	8
11	EUX	Enter AU, Y+B	12
12	EL	Enter AL, Y	8
13	ELX	Enter AL, Y+B	12
14	LA	Add Y, 18 bit	8
15	LAX	Add Y+B, 18 bit	12
16	LS	Subtract Y, 18 bit	8
17	LSX	Subtract Y+B, 18 bit	12
20	AA	Add Y, 36 bit	12
21	AAX	Add Y+B, 36 bit	16
22	AS	Subtract Y, 36 bit	12
23	ASX	Subtract Y+B, 36 bit	16
24	MP	Multiply Y	26-48
25	MPX	Multiply Y+B	30-52
26	DV	Divide, Y	48
27	DVX	Divide, Y+B	52
30	IR	Indirect RJ, Y	12
31	IRX	Indirect RJ, Y+B	16
32	EB	Enter B, Y	12
33	EBX	Enter B, Y+B	16
34	JP	Jump, Y	4
35	JPX	Jump, Y+B	8
36	EBK	Enter B, U	8
37	MBK	Modify B, U	12
40	SZ	Store Zero, Y	8
41	SZX	Store Zero, Y+B	12
42	SB	Store B, Y	12
43	SBX	Store B, Y+B	16
44	SL	Store AL, Y	8
45	SLX	Store AL, Y+B	12
46	SU	Store AU, Y	8
47	SUX	Store AU, Y+B	12
51	IOR	Inclusive OR, Y	8
52	LPR	Logical Product, Y	8
53	XOR	Exclusive OR, Y	8
54	IJR	Indirect Jump (RIL), Y	8
55	IJP	Indirect Jump, Y	8
56	BSK	B Skip, Y	16
57	XSK	Index Skip, Y	12
60	ZJU	Jump AU Zero, Y	4
61	ZJL	Jump AL Zero, Y	4
62	VJU	Jump AU Not Zero, Y	4
63	VJL	Jump AL Not Zero, Y	4
64	PJU	Jump AU Positive, Y	4
65	PJL	Jump AL Positive, Y	4
66	NJU	Jump AU Negative, Y	4
67	NJL	Jump AL Negative, Y	4
70	ELK	Enter AL, U	6
71	AKL	Add U, 12 bits	6
72	SIC	Store ICR, Y	8
73	BJP	B Jump, Y	12
74	SAD	Store Address, Y	8
75	SSR	Store SR, Y	8
76	RJP	Return Jump, Y	8
5011	INP	Initiate Input Buff, k	20
5012	OUT	Initiate Output Buff, k	20
5013	EXF	Initiate Ext Function Buff, k	20
5015	TIN	Force Term Input, k	4
5016	TOU	Force Term Output, k	4
5017	TFN	Force Term Ext Function, k	4
5020	SRM	Set Resume ff (Intercomp)	4
5021	SKI	Skip Input Inact, k	6
5022	SKO	Skip Output Inact, k	6
5023	SKF	Skip Ext Function Inact, k	6
5024	WFI	Wait for Interrupt	4
5026	FSO	Force Output One Word, k	4
5027	FSF	Force Ext Function One Word, k	4
5030	RIL	Enable All Interrupts	4
5032	RXL	Enable Ext Interrupts	4
5034	SIL	Set Interrupt Lockout	4
5036	SXL	Set Ext Interrupt Lockout	4
5041	RSU	Shift AU Right, k	4+.67k
5042	RSL	Shift AL Right, k	4+.67k
5043	RSA	Shift A Right, k	4+.67k
5044	SFA	Scale A Left, k, SF	8+.67n
5045	LSU	Rotate AU Left, k	4+.67k
5046	LSL	Rotate AL Left, k	4+.67k
5047	LSA	Rotate A Left, k	4+.67k
5050	SKK	Skip Console Key, k	6
5051	SNB	Skip No Borrow	6
5052	SOV	Skip Overflow	6
5053	SNV	Skip No Overflow	6
5054	SOP	Skip L(AU,AL) Odd Parity	6
5055	SEP	Skip L(AU,AL) Even Parity	6
5056	STP	Stop Console Key, k	4
5057	SNR	Skip Resume ff (Intercomp)	6
5060	RND	Round AU	6
5061	CPL	Complement AL	6
5062	CPU	Complement AU	6
5063	CPA	Complement A	6
5072	EIC	Enter ICR, k	4
5073	ESR	Enter SR, k	4

Table 6.8-2 Performance Specifications on the Ampex Model FR-600 Magnetic Tape Recorder

Parameter	Specification
Reel size	14 inch or 10-1/2 inch, Ampex precision or NAB
Starting Time	Tape Speed (ips) / 250-kc System (Seconds) / 500-kc System (Seconds) 120 — 8 60 — 7 — 7 30 — 5 — 6 15 — 5 — 9 7-1/2 — 8
Stopping time	Max 2.5 seconds at 60 ips Max 3 seconds at 120 ips
Rewind and fast forward time	For 14-inch reel, with 5000 feet of tape, approximately 3 minutes
Flutter and wow	Below 0.3% peak-to-peak, cumulative from 0.2 cps to 10 kc at 60 ips
Frequency response	Tape Speed (ips) / Bandwidth (cps) 120 — 300 - 500,000 ±3db 60 — 300 - 250,000 ±3db 30 — 150 - 125,000 ±3db 15 — 100 - 60,000 ±3db 7-1/2 — 100 - 30,000 ±3db
Signal-to-Noise ratio	120 ips — 32 db 60 — 30 db 30 — 30 db 15 — 30 db 7-1/2 — 30 db
Heads Gap Scatter	Trailing edges for record heads (or gap centers for reproduce heads) within a band 100 microinches wide (0.000 1 inch)
Gap Azimuth	All stacks within ± 1 minute of arc perpendicular to head base plate

Table 6.8-2 Continued

Parameter	Specification
Track Dimensions	Track width is 0.050 inch; tape track spacing 0.070 inch on center. Voice track width 0.005 inch on 1/2 inch heads; 0.010 inch on 1 inch heads.
Number of tracks	7 on 1/2 inch; 14 on 1 inch, both plus voice track
Inter-track Spacing	1.5 $\pm$0.0005 inches
Input level	1.0 volt RMS nominal to produce normal recording level; adjustable from o.25 to 25 volts RMS by input potentiometer
Input impedance	Minimum 10,000 ohms resistive, in parallel with 200 micromicrofarads, unbalanced to ground.
Output level	1.0 volt RMS nominal across 1,000 ohms or greater impedance, adjustable from 0 to 2 volts.
Output impedance	Less than 100 ohms.
Power requirements	
Voltage	117 volts, single phase, 58 to 62 cps AC (48 to 52 cps AC on special order)
Power consumption	Approximately 1,200 watts for a 7-track record/ reproduce system. 1400 watts for a 14-track system.
Environment	
Temperature	Operating 40° F to 125° F
Relative Humidity	Up to 95%

Table 6.8-3 Performance Specifications on the Magnacord Model 728 Dual-Track Magnetic Tape Recorder

Parameters	Specification
Reel size	Up to 10-1/2 inches NARTB
Tape speed	7.5 and 15 ips, direct drive
Starting time	Less than 0.2 sec
Stopping time	Less than 2 inches of tape when operating at 15 cps
Rewind and fast forward time	1600 feet per minute
Playing time	30 minutes at 7.5 ips with 1200 feet, 1.5 mil tape
Timing accuracy	± 3 seconds in 30 minutes
Flutter and wow	0.1% at 15 ips, 0.15% at 7.5 ips
Frequency response	40 to 15,000 cps, 22db at 7.5 ips; 30 to 18,000 cps, ±2db at 15 ips
Signal-to-noise ratio	Better than 55 db per channel
Cross talk	Better than 55 db per channel
Heads	Erase head, split stereo Record head and reproduce head are in-line stereo
Remote control	With single pole/single throw switch installed, the recorder may be start-stopped in any mode of operation.
Input sensitivity	-90dbm to -30dbm
Input	Two high-impedance microphones (for use with two 250,000 ohm impedance unbalanced bridge inputs) Two low-impedance microphones (for use with optional input transformers 50,000 ohm impedances)

Table 6.8-3 Continued

Parameters	Specification
Output	Cathode follower (for use with unbalanced line, minimum load impedance 20,000 ohms) 600 ohm balanced line (for use with optional input transformers)
Input power requirements	117 volt, 60 cycles, 200 watts

Table 6.8-4 Performance Specifications on the Ampex Model FR114B Magnetic Tape Recorder

(To be supplied later)

Table 6.8-5 Performance Specifications on the Sanborn Direct Write Strip Chart Recorder

(To be supplied later)

Table 6.8-6 Performance Specifications on the Honeywell Model 906B (Visicorder) Strip Chart Recorder

(To be supplied later)

Table 6.8-7 Performance Specifications on the Brush Model 429988-910 (Events) Strip Chart Recorder

(To be supplied later)

Table 6.9-1 Performance Specifications on the Aeromedical Monitor Console

(To be supplied later)

Table 6.9-2 Performance Specification on the Agena System Monitor Console

(To be supplied later)

Table 6.9-3 Performance Specifications on the Command Communications Console

(To be supplied later)

Table 6.9-4 Performance Specifications on the Gemini System Monitor Console

(To be supplied later)

Table 6.9-5 Performance Specifications on the Maintenance and Operation Console

(To be supplied later)

Table 6.10-1 Performance Specifications on the Teletypewriter Model 28 ASR Send-Receive Unit

(To be supplied later)

Table 6.10-2 Performance Specifications on the Teletypewriter Model 28 RO Receive Only Unit

(To be provided later)

Table 6.10-3 Performance Specifications on the Teletypewriter Model 28 ROTR Receive Only Typing Reperforator

(To be provided later)

Table 6.10-4 Performance Specifications on the TMC Model GPT-10K High Frequency Transmitter

(To be provided later)

Table 6.10-5 Performance Specifications on the TMC Model TER-5000 Transmitting Dissipator

(To be provided later)

Table 6.10-6 Performance Specifications on the TMC Model DDR-6 Dual Diversity Receiver

(To be provided later)

Table 6.10-7 Performance Specifications on the TMC Model HFD Antenna Multicoupler

(To be provided later)

Table 6.10-8 Performance Specifications on the TMC Models TS-101 and TS-102 Multiplex Units

(To be provided later)

Table 6.11-1 Performance Specifications on the Timing Central WWV

(To be provided later)